FACULTY OF TECHNOLOGY

INFLUENCE OF PROCESS MINING IN ROBOTIC PROCESS AUTOMATION

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ABSTRACT

Influence of Process Mining in Robotic Process Automation

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Supervisors at the university: Kauppila Osmo, Reiman Arto

Companies are in an on-going competition against each other of the customers’ favour. Customers demand cheaper products and services with better quality. To be able to meet the customer requirements and stand up against their competitors, companies must be able to do more with less money and time invested. For this reason, process automation has been implemented widely in various companies. The latest breakthrough within process automation has been the implementation of Robotic Process Automation (RPA) which automatizes simple and rule-based back office tasks. While the existing literature reports high return on investment for RPA, challenges in identifying the best use cases to receive these returns remain.

Some studies have suggested to combine RPA with Process Mining (PM) technology to help with this challenge. PM itself is still an emerging technology much like RPA. While both of these technologies have been studied somewhat, their combination remains undiscovered by prior literature. Therefore, the ambition of this research is to generate new understanding on how Process Mining can influence the efficiency of RPA’s utilisation.

This ambition is achieved with a qualitative interview study that answers the following research questions:

- RQ1: What are the benefits of RPA?
- RQ2: What are the pre-requisites for successful RPA?
- RQ3: How can process mining influence the efficiency of RPA?

To answer the research questions, a literature review consisting of Business Process Management, RPA, and PM was conducted. The literature review forms an understanding of the key elements of RPA and PM while also identifying why businesses need these technologies. Interviews were conducted with professionals who had experience on RPA and PM to validate and expand the literature findings and to identify how RPA and PM could be combined. Combining the findings of literature review and interviews, a framework for RPA lifecycle augmented with PM was created to illustrate how RPA and PM can be beneficially combined.

The results of this research reveal that PM is able to improve the efficiency of RPA by enabling data-based process understanding for organizations which helps to identify the best opportunities for automation, spot pre-automation process improvement needs, and to support decision making. In addition, PM is able to monitor and analyse the performance of the processes and the RPA robots to spot any deviances and to report the realized benefits of applying RPA to the process.

This research contributes to the existing literature by providing new knowledge about the combination of RPA and PM. These results can be generally applied within organizations using RPA without restrictions to their industries.

Keywords: business process management, robotic process automation, process mining, process improvement

TIIVISTELMÄ

Influence of Process Mining in Robotic Process Automation

Jaakko Knuutinen

Oulun yliopisto, tuotantotalous

Diplomityö, 2020, 116 sivua, 1 liite

Ohjaajat yliopistolla: Kauppila Osmo, Reiman Arto

Yritykset kilpailevat jatkuvasti toisiaan vastaan asiakkaidensa suosiosta. Asiakkaat vaativat halvempia ja laadukkaampia tuotteita ja palveluita. Vastatakseen asiakasvaatimuksiin ja säilyttääkseen kilpailukykynsä, yritysten täytyy tehdä enemmän asioita pienemmillä rahallisilla ja ajallisilla investoinneilla. Vastauksena tähän tarpeeseen, monet yritykset ovat automatisoineet prosessejaan. Viimeisin läpimurto prosessiautomaatiossa on ohjelmistorobotiikka, joka automatisoi yksinkertaisia ja sääntöpohjaisia tukitoimintojen työtehtäviä. Tämänhetkinen kirjallisuus raportoi suurta tuottoa investoinneille ohjelmistorobotiikkaan, mutta haasteita tuoton todelliseen toteutumiseen aiheutuu parhaiden käyttökohteiden tunnistamisen vaikeudesta.

Muutamat tutkimukset ovat väläyttäneet prosessilouhinnan yhdistämistä ohjelmistorobotiikkaan, jotta parhaiden käyttökohteiden tunnistaminen helpottuisi. Prosessilouhinta, kuten ohjelmistorobotiikka, on myös kasvava teknologia. Sekä ohjelmistorobotiikkaa että prosessilouhintaa on tutkittu aikaisemmin, mutta näiden teknologioiden yhdistämistä ei ole juurikaan tutkittu aiemmin. Tästä syystä tämän tutkimuksen päämääränä on luoda uutta ymmärrystä siitä, miten prosessilouhinta vaikuttaa ohjelmistorobotiikan hyödyntämiseen.

Tähän päämäärään päästään laadullisella haastattelututkimuksella, joka vastaa seuraaviin tutkimuskysymyksiin:

- TK1: Mitkä ovat ohjelmistorobotiikan hyödyt?
- TK2: Mitä ennakkovaatimuksia onnistuneelle ohjelmistorobotille on?
- TK3: Kuinka prosessilouhinta voi vaikuttaa ohjelmistorobotiikan tehokkuuteen?

Tutkimuskysymyksiin vastataan tekemällä aluksi kirjallisuuskatsaus, joka koostuu liiketoimintaprosessienhallinnasta, ohjelmistorobotiikasta ja prosessilouhinnasta. Kirjallisuuskatsaus luo ymmärrystä ohjelmistorobotiikan ja prosessilouhinnan perusteista sekä tunnistaa, miksi liiketoiminta tarvitsee näitä teknologioita. Kirjallisuuskatsauksen löydösten validointia ja laajentamista varten toteutettiin haastatteluja alan ammattilaisten kanssa, joilla oli työkokemusta ohjelmistorobotiikasta ja prosessilouhinnasta. Haastattelujen pohjalta pyrittiin myös tunnistamaan, miten prosessilouhintaa ja ohjelmistorobotiikkaa voitaisiin yhdistää. Kirjallisuuskatsauksen ja haastattelujen tulosten yhdistämisen ja analysoinnin pohjalta luotiin viitekehys ohjelmistorobotiikan elinkaarelle, johon liitettiin prosessilouhinnan käyttökohteet. Tämän viitekehyksen tarkoituksena on havainnollistaa, miten ohjelmistorobotiikkaa ja prosessilouhintaa voidaan hyödyntää yhdessä.

Tutkimustulokset osoittavat, että prosessilouhinnan mahdollistama dataan perustuva prosessiymmärrys auttaa organisaatioita tunnistamaan parhaat käyttökohteet automaatiolle, havaitsemaan prosessinkehitys tarpeita sekä tukemaan päätöksentekoa, mitkä puolestaan parantavat ohjelmistorobotiikan tehokkuutta. Näiden lisäksi prosessilouhinnan avulla pystytään monitoroimaan ja analysoimaan prosessien ja robottien suorituskykyä, jolloin voidaan havaita mahdolliset poikkeamat sekä raportoimaan saavutetut hyödyt ohjelmistorobotiikan käytöstä prosessissa.

Tämä tutkimus tukee aiempaa tutkimustietoa luomalla uutta tietoa ohjelmistorobotiikan ja prosessilouhinnan yhdistämisestä. Tutkimuksen tuloksia voidaan soveltaa yleisesti ohjelmistorobotiikkaa käyttävissä organisaatioissa toimialasta riippumattomasti.

Avainsanat: liiketoimintaprosessienhallinta, ohjelmistorobotiikka, prosessilouhinta, prosessinkehitys

FOREWORD

This thesis was conducted for QPR Software Oy during year 2020 from February to October. During the master's thesis project, I was also able to work with various process mining topics at QPR. The main purpose of the thesis was to learn more about how process mining and RPA can work together, and this goal was successfully achieved. I am excited to continue working at QPR as process mining is a super interesting technology that combines various topics of my studies in Industrial Engineering and Management.

First of all, I would like to thank QPR Software and all of my colleagues for this possibility and the support while learning the ropes of process mining. I would especially like to thank Olli Komulainen for being a fantastic manager and supervisor. Sparring various topics has been a great help in this project! I would further like to give my gratitude to my supervisors Osmo Kauppila and Arto Reiman from University of Oulu for your more scientific guidance during this project. I also want to thank all the interviewees that participated in this study for your time and comments.

I want to thank my family, friends, and girlfriend who have always supported me before and after my studies, and whom I can always rely on. Lastly, I want to express my gratitude to all the great friends I have been able to meet during my studies. You have made this part of my life unforgettable, and I highly appreciate all the great moments we have had during these last five years!

Espoo, 30.10.2020

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1 INTRODUCTION

1.1 Study background

Businesses are in a constant competition with their competitors for customers who demand faster, better, and cheaper products and services. The ability to provide products and services that meet the customer requirements is determined by the business processes within an organization. Therefore, to meet the ever-changing customer needs, organizations need to focus on managing and improving their processes. (Fullerton & McWatters 2001; Snee 2010; Trkman 2010; van der Aalst 2012; Meidan et al. 2017)

Process automation is one common way to improve the performance and reduce the costs of business processes. Traditionally, process automation has been concerned about creating back-end changes to the business logic and data access layers. However, recently a new technology called Robotic Process Automation (*hereinafter* RPA) has gathered interest in the business with its relatively fast implementation and high return on investment. In order to achieve the desired benefits of RPA, the most optimal use cases for automation need to be identified. (Willcocks et al. 2015a; Willcocks et al. 2015b; Suri et al. 2017; van der Aalst et al. 2018; Cooper et al. 2019) This is especially important as "automating a bad process can destroy the return on your RPA investment" (PricewaterhouseCoopers 2017).

The opportunities for using RPA can be spotted and prioritized by combining process mining, another emerging technology, with RPA. Process mining (*hereinafter* PM) is a relatively young field of process management that combines machine learning and data mining with a process perspective. In process mining it is possible to use the enormous amounts of data available in modern information systems to model, analyse, and reveal the real behaviour of organization's business processes. (van der Aalst et al. 2012; van der Aalst 2016; Di Francescomarino et al. 2018; Dumas et al. 2018; García-Bañuelos et al. 2018). While there have been some suggestions regarding the benefits (e.g. speeding up the early stages of RPA development) of combining PM with RPA (van der Aalst 2016; Jimenez-Ramirez et al. 2019; Kerremans et al. 2020; Kokina & Blanchette 2019), the topic has not been covered properly in the current literature. Therefore, this research aims to discover how process mining can be used to improve the efficiency of process automations utilizing RPA.

1.2 Research objectives and structure

The main objective of this research is to develop a better understanding on how analysis done with process mining can influence the efficiency of RPA. RPA and PM are both relatively young technologies which makes them a relatively new field of research as well. Prior studies have implied that combining the use of RPA and PM could help with the implementation of RPA and lead to better return on investment. However, there are no in-depth studies conducted on this combination. Therefore, this study clarifies the desired benefits of RPA and the pre-requisites of implementing RPA. Additionally, the steps of RPA are studied in order to better understand, where PM can be useful.

To be able to understand and identify how PM influences RPA, a literature review on various elements of RPA and the capabilities of PM is conducted. The literature review is coupled with an empirical interview study to discover how the key elements of RPA and PM behave and appear in practice. Additionally, to understand why technologies such as RPA and PM are used to begin with, the literature review includes research on the management and improvement of business processes. The output of this study provides new information to organizations on how to use PM to get the most out of their investments in process automation with RPA in the form of an RPA lifecycle framework. Next, the research questions used to reach these objectives are presented.

RQ1: What are the benefits of RPA?

The goal is to discover those desired benefits that provide the return on investment for RPA, and therefore, guide the implementation decisions of RPA. The prior literature on the benefits of RPA is researched to identify the theoretical benefits of RPA. Interviews with professionals that have experience on RPA are conducted to verify these benefits. Finally, the found benefits are analysed and categorized to highlight those benefits that have the strongest influence over decisions regarding RPA’s utilisation.

RQ2: What are the pre-requisites for successful RPA?

The objective here is to discover what kind of disadvantages, challenges, and criteria there are to consider when implementing or using RPA as these are key elements that can hinder the realization of the desired benefits of RPA. Prior studies discussing these elements are researched to form a basic understanding about where RPA should and should not be used. The literature review is followed by interviews conducted with professionals with experience on RPA to what are the most influential challenges and risks of RPA in practice. The theoretical and practical findings are analysed and categorized together to identify the most important pre-requisites for utilisation of RPA.

RQ3: How can process mining influence the efficiency of RPA?

The last research question focuses on finding PM can be used to boost the benefits of RPA or to hinder the effects of disadvantages, challenges, and risks on RPA's success. The prior literature on PM is researched to understand how and where PM can be used. Interviews are conducted with professionals that have experience on both RPA and PM to find out how PM can be used improve RPA's efficiency and to understand what the key limitations are for using PM together with RPA. These findings are analysed and categorized to build an RPA lifecycle that is integrated with potential use cases for PM.

The scope of this study is to focus on process automation done with RPA and how PM can be used within this domain. While there are many different ways to manage and improve business processes, this thesis only briefly discusses them. Similarly, there are many different ways to automate processes. This research does not delve deep into the other ways of automating business processes, but it does consider which types of situations are most suitable for RPA and which are better left for other methods of automation. Furthermore, PM can be used for many different purposes other than RPA. However, this thesis does not deeply discuss all of the use cases of PM, but rather focuses on the use cases concerning RPA domain.

1.3 Research process

This research is conducted as a qualitative interview research and the research process is illustrated in Figure 1. The research data is composed of previous literature and semi-structured interviews discussed more precisely in section 3. The study began by presenting the background of the topics, identifying the need for this research, and introducing the research objectives and questions. The research continues with a literature review on the three main topics of this thesis: Business Process management, Robotic Process Automation, and Process Mining. The results of the literature review are summarized at the end of the second chapter before moving on to the empirical part of the thesis.

The empirical part of the thesis consists of analysing the interview results. The interview topics are divided to four main categories that mostly cover the literature topics, providing a practical view of them. However, the fourth category, 'PM within RPA domain' was not covered in the prior literature and is therefore solely based on the discussions had in the interviews. After the interview results have been analysed, the theoretical and empirical findings are combined to formulate answers to the research questions. Finally, the key findings and final answers to the research questions are provided along with an evaluation of the results.

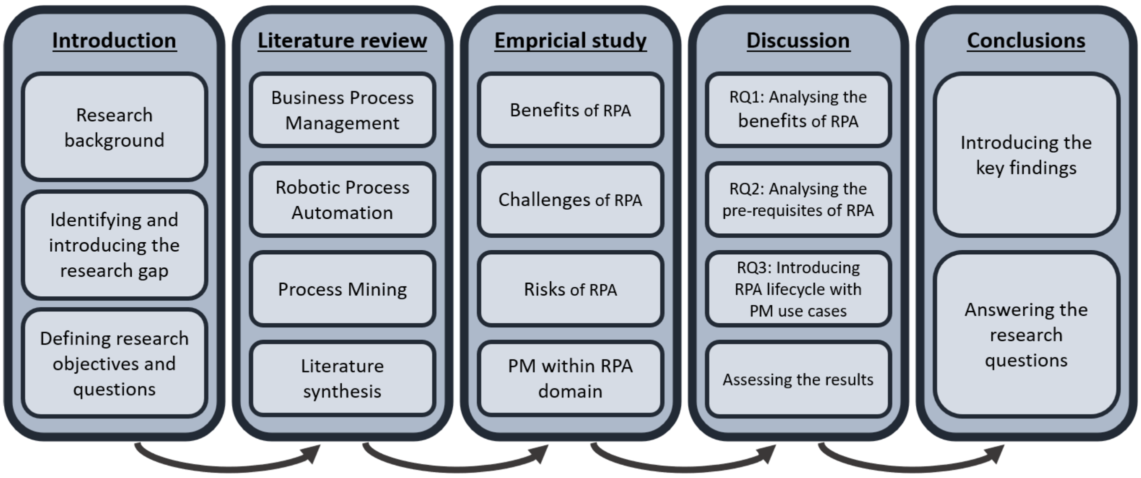

Figure 1. The research process of this thesis.

2 LITERATURE REVIEW

This chapter provides the reader with a review of the scientific literature on Business Process Management (*hereinafter* BPM), Robotic Process Automation, and Process Mining. Firstly, in section 2.1 BPM is introduced to give the reader an overview on the literature of process-centric thinking of business operations which is also the foundation for RPA and PM, discussed in sections 2.2 and 2.3, respectively. Secondly, this chapter covers quite thoroughly the present literature on RPA. Here, various benefits, disadvantages, challenges, process criteria, and use cases for RPA are studied to find out the prerequisites for RPA. This is followed by a comparison between RPA and Business Process Automation. Finally, the implementation of RPA is discussed to give some light on the practical application of RPA. Thirdly, the literature on PM is reviewed to study how PM can be used and what are the prerequisites for using PM.

As the result of the review on scientific literature, a general framework for applying RPA is created. This framework is based on the general BPM lifecycle presented by Dumas et al. (2018), but it is modified specifically with RPA in mind. The framework is updated later on in chapter 5 with PM use cases.

2.1 Management and improvement of business processes

The main topics in management and improvement of business processes are business processes, process categories and relationships, process modelling, and the success factors in process improvement. The goal of this section is to provide the reader with an overview on what business processes are, why they are important, and how they have been managed and improved in the past. This understanding is essential for understanding the later sections regarding RPA and PM.

The on-going competition in business forces organizations to re-examine and improve the performance of their business (Fullerton & McWatters 2001). According to Meidan et al. (2017), proper management of business processes can help organizations to achieve their objectives. In addition to competition on the markets, the business environments and customer needs tend to change overtime. Moreover, business processes do not improve by themselves, instead, they deteriorate. Therefore, to be able to put up against their competitor's and achieve long-term growth, organizations need to continuously improve their performance. (Snee 2010; Trkman 2010; van der Aalst 2012)

To be able to continuously improve the performance of organizations, various different management disciplines have emerged starting from the quality movement inspired by the works of Deming (1986) and Juran (1989). The goal behind the different management disciplines such as Total Quality Management, Just-in-Time, Business Process Reengineering, Business Process Management, Lean, Six Sigma, and Lean Six Sigma is essentially the same: improving business performance by focusing on the organization's processes. However, Business Process Reengineering derives itself from the other methods with its specific focus on radical changes to a process while the other methodologies tend to have more emphasis in incremental changes or combining both methods. (Calvasina 1989; Zipkin 1991; Davenport 1993; Hammer & Champy 1995; Samson & Terziovski 1999; Fullerton & McWatters 2001; Arnheiter & Maleyeff 2005; Hung 2006; Näslund 2008; Snee 2010; Harmon 2015; vom Brocke & Rosemann 2015) Moreover, vom Broke et al. (2016) suggest that it is unlikely that one single BPM approach would fit all the needs and requirements set to the BPM program. In this thesis, BPM is defined as a broad management discipline that combines all of these methodologies as the concepts of RPA and PM can be applied to each of them (Harmon 2015).

Business process management consists of both radical and incremental methods, techniques, tools, and information technology (*hereinafter* IT) that allow organizations to focus on their business processes, define key performance indicators (KPIs), and continually improve and innovate their performance (van der Aalst et al. 2003; Weske et al. 2004; Hung 2006; Ko et al. 2009; Trkman 2010; Snee 2010; van der Aalst 2012; Harmon 2015; vom Brocke & Rosemann 2015; Rahimi et al. 2016; Meidan et al. 2017; Dumas et al. 2018). A generic framework for BPM can be seen from Figure 2. The BPM lifecycle is a continuous cycle of different phases of process improvement. Each of these phases take advantage of a given set of techniques and they support one another. (Dumas et al. 2018)

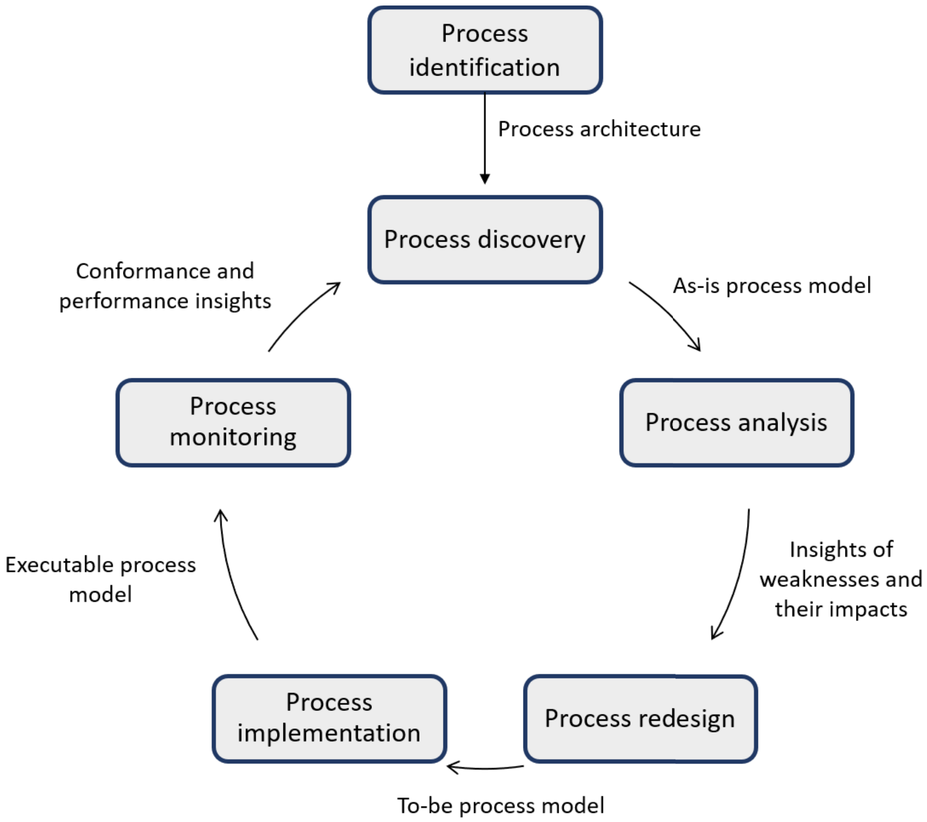

Figure 2. The BPM lifecycle (Adapted from Dumas et al. 2018).

The goal of BPM is to improve operational performance to fulfil organization's strategic targets, with specific focus on the processes having most impact on customer satisfaction while reducing the costs of operation (Davenport 1993; Samson & Terziovski 1999; Arnheiter & Maleyeff 2005; Hung 2006; Näslund 2008; Trkman 2010; van der Aalst 2012; Harmon 2015; van der Aalst et al. 2016). The focus on business processes alone does not directly result to fulfilled strategic targets, but BPM allows companies to understand the performance and relationships of their operations, making them more flexible and better aligned with corporate strategies (Snee 2010; Trkman 2010; Weske 2012; Dumas et al. 2018). In addition, BPM is strongly integrated with IT management as it may use software and technology (e.g. process automation) to reach the goals set to it. However, BPM does not necessarily always attempt to integrate new technologies to the operations. (Hung 2006; Ko et al. 2009; Rahimi et al. 2016; van der Aalst et al. 2016)

2.1.1 BPM success factors

Trkman (2010), van der Aalst et al. (2016), Meidan et al. (2017), and Dumas et al. (2018) emphasize that BPM must be based on strategic objectives to have success and real effect on the operational performance. The focus on strategic objectives is essential to be able to compete in today's global markets and to drive for long-term benefits, performance improvements, and competitiveness (Hung 2006; Trkman 2010; van der Aalst et al. 2016; Meidan et al. 2017; Dumas et al. 2018). In addition, the goals of organization influence the method how BPM should be implemented (Rahimi et al. 2016; vom Broke et al. 2016). As such changes in an organization are typically large in scope, span over a long time, and are difficult to execute, BPM also needs to empower employees and ensure top management's strong commitment to the cause in order to have success (Hammer & Champy 1995; Hung 2006; Snee 2010; Dumas et al. 2018). BPM can be said to be successful when it is able to make processes continuously contribute more towards strategic goals, both within the scope of a single project and over a longer time period (Trkman 2010; van der Aalst 2012; Meidan 2017). To measure how well the strategic targets are fulfilled, KPIs are defined and monitored for each process (van der Aalst et al. 2016).

Continuous monitoring and improvement of KPIs is necessary, as Hammer & Champy (1995, p. 34) put it: "*A truly great company is never satisfied with its current performance*". KPIs are unambiguously determined qualities of a business process that can be calculated for a given process (Dumas et al. 2018). Some examples of typical KPIs include: reduced defects; reduced amount of non-value adding work; reduced cycle times; improved customer satisfaction; improved quality; reduced costs; and the competitive advantage through innovation (Calvasina et al. 1989; Zipkin 1991; Samson & Terziovski 1999; Fullerton & McWatters 2001; Arnheiter & Maleyeff 2005; Hung 2006; Trkman 2010; Snee 2010; Dumas et al. 2018).

2.1.2 Business processes

Everything a company delivers to its customers is made in a business process and the quality of these deliverables is affected by how the process is designed and performed. Moreover, the processes behind these deliverables (products and services) determine companies' long-term success. (Hammer & Champy 1995; Dumas et al. 2018). Hence, the management of business processes is critical to the success of any organization. BPM does not focus on individual activities, instead, the main tool used in BPM are the entire chains of activities – processes (Weske 2012; Dumas et al. 2018). A business process takes an input and performs a chain of coordinated activities to it, turning it into a more valuable output, ultimately leading into added value to the organization and its customers (Hammer & Champy 1995; Toor & Dhir 2011; Weske 2012; Dumas et al. 2018). Business processes are also used to link business strategy into organization's IT capabilities (Rahimi et al. 2016). However, business processes need to be standardized before they can be supported by technological solutions (Trkman 2010). Otherwise one may end up doing the wrong thing more efficiently (Hammer & Champy 1995).

All organizations are made of processes and have multiple different processes to manage. Some of the most typical processes are order-to-cash, quote-to-order, procure-to-pay, issue-to-resolution, and application-to-approval. The names of these processes can vary depending on the source, but the result stays the same. (Davenport 1993; Hammer & Champy 1995; Dumas et al. 2018) The outputs of these processes can serve as an input to other processes, creating a supplier-customer relationship between them which might cross organizational boundaries. (Weske 2012; Dumas et al. 2018) The various types of processes have been categorized into core, support, and management processes based on Porter's Value Chain (Dumas et al. 2018). *Core processes* are those that are essential to the value creation of a company, having a strategic importance on organization's success, and for which customers are willing to pay for (Hung 2006; Trkman 2010; Toor & Dhir 2011; Dumas et al. 2018). *Support processes* are enablers of the core processes, but something the customer is not willing to directly pay for. Neither will the customers pay for *management processes*, but they are still essential since they provide guidelines, rules, and directions for core and support processes. (Toor & Dhir 2011; Dumas et al. 2018) Sometimes the support and management processes may not be distinguished as separate process types, instead, they may be combined into a single category as done in Trkman (2010), for example. According to Dumas et al. (2018), the distinction of processes into these three categories is strategically important for companies. In Figure 3, this categorization is used to group different processes according to their strategic importance, such a representation is called *process landscape.* Process landscape provides a high-level view of the organization's process architecture with use of value chains. (Dumas et al. 2018)

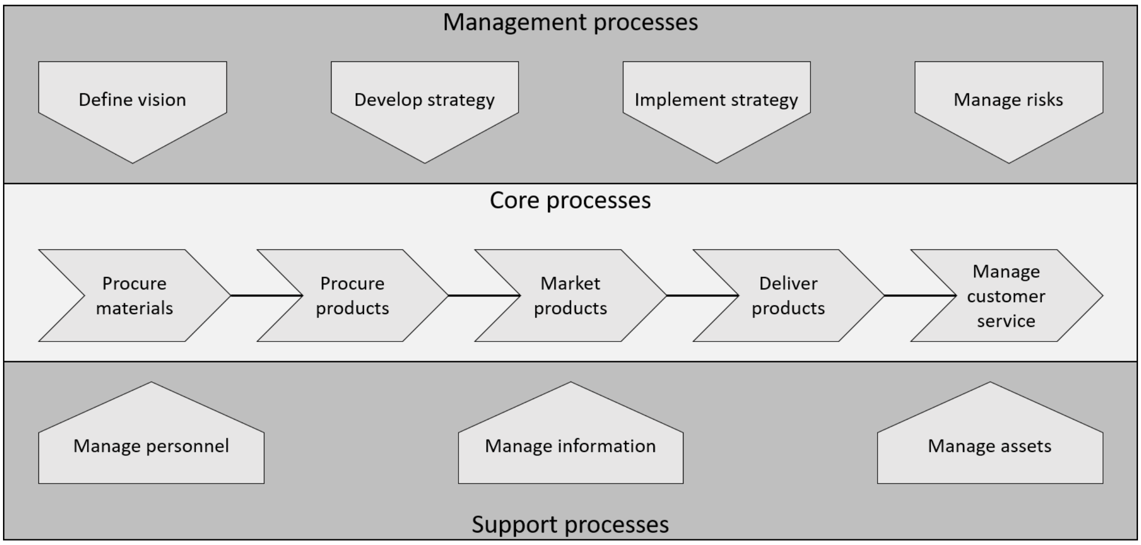

Figure 3. An example of processes grouped by categories into a process landscape (Adapted from Dumas et al. 2018).

As can be seen from the process landscape in Figure 3, processes create relationships between one another. There exist three types of relationships between processes which are illustrated on Figure 4. Sequence, also called horizontal relationship, showcases a logical sequence between two processes. (Dumas et al. 2018) Decomposition is used to describe a given process in more detail (Toor & Dhir 2011; Dumas et al. 2018). Lastly, Specialization indicates several existing variants of a process (Dumas et al. 2018). Defining the process landscape model should be done in a systematic fashion and involves all major stakeholders and is typically done by interviews or in a workshop setting (Dumas et al. 2018). A well-defined process landscape allows stakeholders in an organization to understand the major processes of the organization which helps with identifying needs for improvement (Dumas et al. 2018).

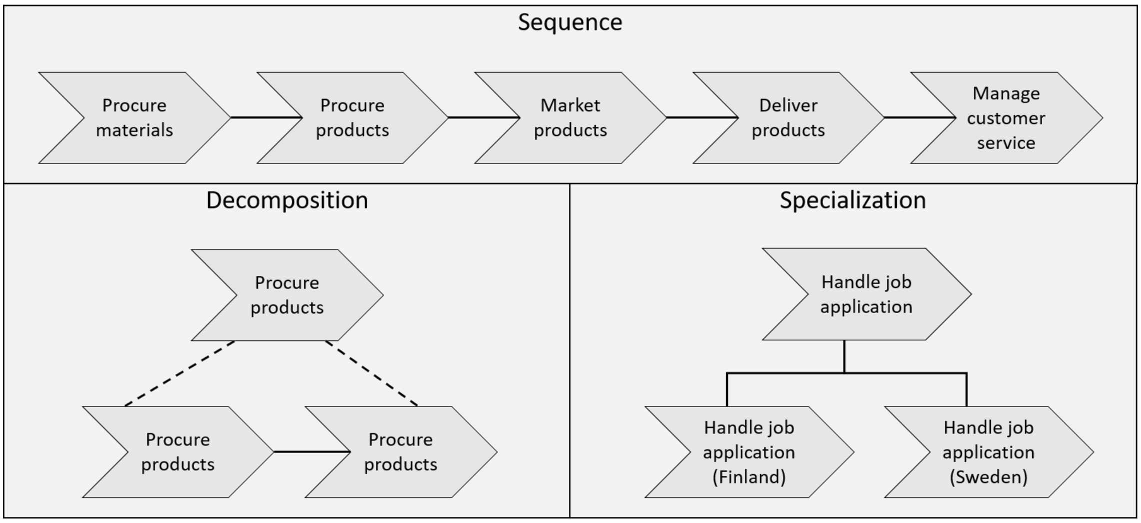

Figure 4. Process relationships (Adapted from Dumas et al. 2018).

2.1.3 Process modelling

Process modelling is an essential part of managing business processes (Toor & Dhir 2011; Reijers et al. 2015). Process models are blueprints of business processes that aim to provide insights by representing the activities and their relationships required to execute a process. Process models can be used to configure information system, but they are also very useful for analysing, understanding, and improving processes, for example, by identifying issues in the process. (Davenport 1993; Hammer & Champy 1995; Weske et al. 2004; Toor & Dhir 2011; van der Aalst et al. 2012; Weske 2012; Reijers et al. 2015; Dumas et al 2018) In addition, process models make communication about a process easier and more effective between stakeholders as there are typically many disagreements on how the process is executed (Hammer & Champy 1995; Weske 2012; Polyvyanyy et al. 2015; Reijers et al. 2015; Dumas et al. 2018). Van der Aalst et al. (2016) emphasize that process models are not very useful if they are not used to actually improve processes. In order to improve processes, they need to be understood which can be difficult without process models as modern processes are complex and heavily relied in information systems (van der Aalst et al. 2012; Polyvyanyy et al. 2015; Reijers et al. 2015).

Process modelling can be done using textual descriptions or diagrams, however, using solely textual description can be easy to misinterpret. Nowadays, a common way for process modelling is to use some type of business process modelling language. There are many different modelling languages, but essentially, they are different types of flowcharts. Today, the most common process flowchart notation style is called Business

Process Model and Notation (BPMN). (Weske 2012; Reijers et al. 2015; van der Aalst 2016; Dumas et al. 2018)

However, it should be noted that the process models based on workshops or interviews may not resemble reality of the process execution. Instead, they rely on the information of the process participants who may have knowledge bias and be influenced by norms and expectations of the organization. (van der Aalst et al. 2016) The presence of various information systems provides useful data of organization's real operation. Such operational data can be used to support process improvement initiatives, for example, with the help of process mining (van der Aalst 2012; Reinkemeyer 2020).

2.2 Robotic process automation

Robotic Process Automation is an automation technology using software-based tools to automatize structured and repetitive processes by configuring a software robot to use an organization's information systems presentation layer the same way a human would (Willcocks et al. 2015a; Kääriäinen et al. 2018; Aguirre & Rodriguez 2017; van der Aalst 2018; Moffitt et al. 2018). Even though RPA includes the word 'robot', there are no physical robots used, only software robots. In this context, one robot refers to one software license. (Lacity & Willcocks 2016a) Currently, RPA is not considered to include any cognitive automation tools such as Machine Learning or Artificial Intelligence. However, many sources indicate that these tools are likely to be integrated into RPA in the future as they would allow more widespread adoption of RPA in terms of applicable processes. (Aguirre & Rodriguez 2017; van der Aalst 2018; Santos et al. 2019)

Some might think that RPA will replace the traditional business process automatization (*hereinafter* BPA) solutions, but according to Lacity & Willcocks (2016a) this is not the case. Instead, RPA and BPA are seen to complement each other (Lacity & Willcocks 2016a). The main difference between RPA and BPA is that RPA robots are integrated across IT systems via front-end instead of the back-end as demonstrated in Figure 5 (Aguirre & Rodriguez 2017; Asatiani & Penttinen 2016; Penttinen et al. 2018). This way the existing information systems and business logic remain untouched and the human users are replaced by robot agents (van der Aalst 2018; Lacity & Willcocks 2016a). Implementing RPA is also very different to traditional BPA. RPA implementation is driven by business operations instead of the IT department as in traditional process automation. As RPA requires only small amounts of coding and no redesign of the existing information systems, implementing RPA takes less time and effort compared to back-end automation. (Aguirre & Rodriguez 2017; Asatiani & Penttinen 2016; Lacity & Willcocks 2016a, Penttinen et al. 2018)

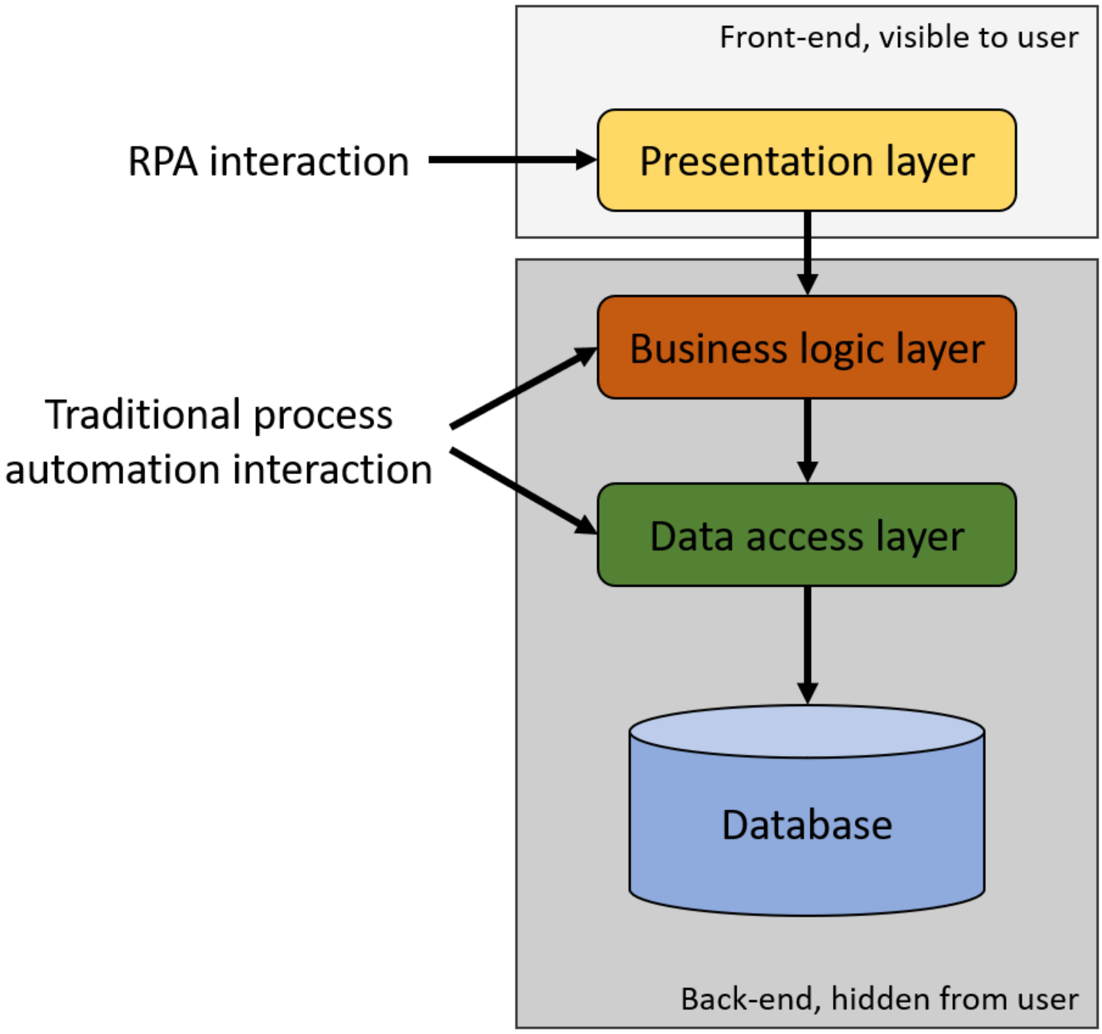

Figure 5. The functional differences between RPA and BPA. (Adapted from Willcocks et al. 2015b)

Requiring less time and effort makes RPA viable for many processes that would otherwise not be worth of the automatization investment when using more IT oriented solutions (Lacity & Willcocks 2016a; van der Aalst 2018). Automatization through RPA is mostly targeted to processes requiring less IT expertise and more process knowledge that are small enough to make IT development investment unjustified and impractical (Lacity & Willcocks 2016a). RPA automatically generates code as users (business operations people) with subject and process expertise use drag-and-drop solutions to configure a process, just like when creating a BPMN process model. Therefore, RPA users can be trained in a few weeks and do not need coding skills. (Willcocks et al. 2015a; Lacity & Willcocks 2016a; Hallikainen et al. 2018)

Different studies in the literature cover varying steps for RPA's implementation in terms of how the steps are named or what level of detail in each step is presented. However, all the studies include the same aspects of RPA implementation in their frameworks. The broadest view for RPA's implementation is presented by Santos et al. (2019) in their conceptual model for RPA shown in Figure 6. The model first aligns automation objectives together with organization's strategic goals (Santos et al. 2019) which is also a foundation for enterprise wide RPA adoption (Willcocks et al. 2015b; Moffitt et al. 2018). Then, the model moves towards identifying and selecting the most appropriate processes for automation in the 'process assessment' section. Lastly, tactical evaluation is conducted to study, how RPA implementation should be implemented in each specific situation. (Santos et al. 2019) Next, we will go through these steps more in-depth and discuss them together with other studies.

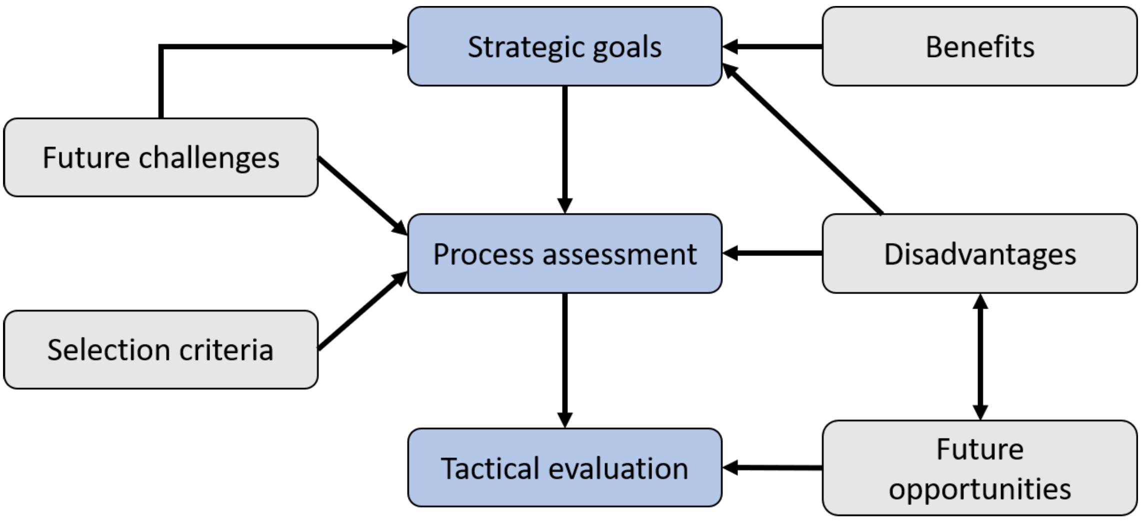

Figure 6. Conceptual model for RPA implementation (Adapted from Santos et al. 2019).

The strategic goals shown in Figure 6 consider the benefits, disadvantages, and future challenges of RPA (Santos et al. 2019). These same qualities are discussed in other studies among business case creation which seems to take place in the strategic goals phase (Suri et al. 2017; Kääriäinen et al. 2018). Kääriäinen et al. (2018) explain that RPA application should be understood as an investment which is based on clear targets for organization's future benefits. These targets are defined based on the qualities of RPA: benefits, disadvantages, and future challenges (Santos et al. 2019). The benefits included in implementing RPA help to set targets for RPA (Suri et al. 2017; Kääriäinen et al. 2018), disadvantages provide limitations for RPA, and future challenges are considered to set appropriate long-term goals (Santos et al. 2019).

2.2.1 Benefits of RPA

The literature reports a wide range of various benefits of implementing RPA. The obvious one is perhaps the fact that robots can work around the clock without salary or breaks, assuming there is no maintenance work needed (Asatiani & Penttinen 2016; Lacity & Willcocks 2016b; Jimenez-Ramirez et al. 2019). Assigning work to a robot therefore delivers reduced full-time equivalent (FTE) costs (Suri et al. 2017) and cost savings as the same tasks are performed by robots who do not require salary (Asatiani & Penttinen 2016; Lacity & Willcocks 2016a; Lacity & Willcocks 2016b; Aguirre & Rodriguez 2017; Ratia et al. 2018; Hallikainen et al. 2018; Huang & Vasarhelyi 2019). In addition to not needing salary, robots are reported to have less errors compared to humans and thus, improving the quality of processes and services which improves customer experience and satisfaction (Willcocks et al. 2015a; Lacity & Willcocks 2016a; Aguirre & Rodriguez 2017; Suri et al. 2017; Ratia et al. 2018; Hallikainen et al. 2018; Kääriäinen et al. 2018; Cooper et al. 2019; Huang & Vasarhelyi 2019; Kokina & Blanchette 2019). The efficiency of processes is also better as robots can handle tasks faster than a human would which reduces the delivery time of a given task and increases the overall process productivity (Lacity & Willcocks 2016a; Asatiani & Penttinen 2016; Suri et al. 2017; Aguirre & Rodriguez 2017; Hallikainen et al. 2018; Kääriäinen et al. 2018; Ratia et al. 2018; Cooper et al. 2019; Huang & Vasarhelyi 2019). However, it is important to note that as Kokina & Blanchette (2019) pointed out, processing speed is an imprecise measure as it is difficult to accurately estimate how long the task takes for a human in reality as people tend to over or underestimate their time usage.

Although many of the above benefits discuss how robots replace humans in performing processes, studies have also witnessed an increase in employee satisfaction due to implementation of RPA (Hallikainen et al. 2018; Kääriäinen et al. 2018; Moffitt et al.

2018; Kokina & Blanchette 2019). This is because software robots mainly replace humans in simple, tedious tasks that require no human skills. As automation is implemented into these simple processes, human workforce is dedicated into more valuable tasks that require human judgement, consideration, and professional expertise. This in turn enriches the work of the employees. (Willcocks et al. 2015b; Lacity & Willcocks 2016a; Suri et al. 2017; Hallikainen et al. 2018; Kääriäinen et al. 2018; Moffitt et al. 2018; Ratia et al. 2018; Cooper et al. 2019; Huang & Vasarhelyi 2019) Freeing human resources for more interesting tasks that require social interaction and judgement also creates more value to the customer which in turn translates to increases in efficiency and productivity in the organizations (Willcocks 2015b; Kääriäinen et al. 2018; Ratia et al. 2018).

As can be seen, the benefits of RPA include economical and qualitative benefits. Evaluation of future benefits of implementing RPA from economical viewpoint include return on investment (ROI) and net present value (NPV) analysis. In the public sector also cost-benefit analysis (CBA) was seen useful. (Kääriäinen et al. 2018) In fact, companies studied have reported a fast ROI for RPA (Lacity & Willcocks 2016a; Lacity & Willcocks 2016b; Hallikainen et al. 2018). RPA is also highly scalable as process libraries, made from the modelled process elements used in different systems (Asatiani & Penttinen 2016), can be reused and updated to the needs of other application areas (Lacity & Willcocks 2016b; Ratia et al. 2018). There exist also some benefits that are not so obvious but, nevertheless, important. Some authors have brought up that RPA increases regulatory compliance in the processes as everything a robot does is logged and can be reviewed (Willcocks et al. 2015a; Cooper et al. 2019). In addition, the processes become better standardized thanks to the implementation of RPA as they are more thoroughly investigated since RPA is best applied to standard processes that do not change (Suri et al. 2017). The last benefit noted in the literature was the flexibility RPA provided. During periods of peak demand, the number of robots can be tuned up to answer the increased demand (Asatiani & Penttinen 2016; Lacity & Willcocks 2016b; Aguirre & Rodriguez 2017; Suri et al. 2017; Jimenez-Ramirez et al. 2019).

2.2.2 Disadvantages of RPA

Moving on to the disadvantages of RPA, the most important one currently is that RPA is only suitable to clearly defined processes with rules-based tasks that do not include subjective decision making (Asatiani & Penttinen 2016; Huang & Vasarhelyi 2019). This is because RPA robots have low accuracy when they need to make decisions based on unstructured data (Jimenez-Ramirez et al. 2019). RPA bots are also expensive to analyse (Jimenez-Ramirez et al. 2019) and when they cannot make a decision, a human worker must be alerted, thus the robots require human supervision (Aguirre & Ramirez 2017). Another disadvantage is that as Asatiani & Penttinen (2016) explain, RPA can only be a temporary fix when used to replace manual tasks in legacy systems. This is because back-end automation with process redesign still has greater performance than RPA's front-end automation does (Asatiani & Penttinen 2016). In addition, RPA can only be applied if the tasks have digital inputs available which can also be a disadvantage (Moffitt et al. 2018; Ratia et al. 2018; Cooper et al. 2019).

Some other disadvantages are related to how RPA changes the way people work and their attitudes. Since robots need to be supervised, they require time from people who could be doing something more productive and valuable. Supervising can also complicate the process as more tasks (the tasks involved in supervising) are introduced to it. (Santos et al. 2019) Asatiani & Penttinen (2016) have brought up the fact that RPA does not have a long-time track record as traditional BPA methods have. Lastly, there is always the risk of workers having a threatened and competitive attitude toward robots which can have a destructive impact on morale, create tension between employees and management, and ultimately lead to sabotaging of RPA implementation (Asatiani & Penttinen 2016; Lacity & Willcocks 2016a; Suri et al. 2017; Hallikainen et al. 2018).

2.2.3 Challenges of RPA

After reviewing the benefits and disadvantages of RPA, we now look at the challenges brought up in the literature regarding RPA. The potential challenges during and after implementation should be considered to be able to evade the problems associated with them (Santos et al. 2019). The initial challenge most companies face in the early adoption of RPA are the concerns among employees of the organization. Employees may feel threatened towards RPA since they fear that the robot will replace them, although, this has rarely been the case. (Willcocks et al. 2015a; Asatiani & Penttinen 2016; Lacity & Willcocks 2016a; Suri et al. 2017; Hallikainen et al. 2018) Another challenge closely related to the above is that people do not understand what RPA is and what it can be used for. This means that companies face the challenge of building in-house competence in RPA to establish cultural adoption for RPA in the organization. (Willcocks et al. 2015a; Lacity & Willcocks 2016a; Suri et al. 2017; Cooper et al. 2019) In addition, Kokina & Blanchette (2019) discovered that implementing RPA seems to require more technology skills from process owners and IT support than commonly advertised by RPA providers.

The lack of understanding of RPA technology has been noted also among IT personnel of organizations. IT personnel easily mistake RPA similar to traditional BPA to which they are more accustomed to. (Willcocks et al. 2015b; Lacity & Willcocks 2016a; Cooper et al. 2019) This may result into problems with the relationships to IT personnel whose support is essential in successfully implementing RPA. Therefore, a challenge is also presented by unclear division of responsibilities between IT and functional operations. (Willcocks et al. 2015a; Willcocks et al. 2015b; Suri et al. 2017) Since RPA needs to have access to databases which can hold confidential information, a likely concern to rise from IT side of the organization is the security of RPA (Kääriäinen et al. 2018; Cooper et al. 2019; Kokina & Blanchette 2019). As Kääriäinen et al. (2018) explain, a vulnerability associated with RPA are outdated background systems that are not updated along the RPA project. On such occasion, a hostile operator may be able to access confidential data by obtaining login information of the RPA robots (Kääriäinen et al. 2018).

The remaining challenges found in the literature are more of a practical nature. Quite many cases report to have challenges in identifying the potential use cases for RPA. This means that companies do not properly distinguish when RPA can be used and how widely within a process it should be used. (Willcocks et al. 2015a; Willcocks et al. 2015b; Kääriäinen et al. 2018; Kokina & Blanchette 2019) Closely related to automatable processes is the standardization of processes which has also been reported as a challenge during implementing RPA. Companies have realized during the implementation that their processes are not as standardized as they thought they are. Especially, the fine level of detail required to configure RPA robots had surprised some companies. (Suri et al. 2017; Kokina & Blanchette 2019) In addition, failures in the normal process lead into process variants which can be challenging to determine during robot design, but such cases still need to be configured separately to the robot (Kokina & Blanchette 2019). Process standardization is important because if a process is automated before ensuring it is functioning properly, RPA might repeat the mistakes with higher efficiency, causing the robot to only make errors faster. Therefore, it is crucial to build the workflow process correctly prior to automation. (Hammer & Champy 1995; Trkman 2010; Ratia et al. 2018) Lastly, large amounts of robot maintenance provide diminishing returns (Kokina & Blanchette 2019).

Sub-sections 2.2.1, 2.2.2, and 2.2.3 have presented the various qualities of RPA that are used to set strategic business goals to RPA implementation. The benefits are used to evaluate the possibilities for RPA, disadvantages are used to determine the limitations of RPA, and the challenges are described to be better prepared for RPA implementation. (Suri et al. 2017; Kääriäinen et al. 2018; Santos et al. 2019) Next, a closer look is taken at what kind of processes can be automated with RPA as process assessment is the second step in the conceptual model for RPA implementation (Santos et al. 2019).

2.2.4 Process criteria for RPA

When it comes to process's suitability for automation with RPA, the nature of the process is the most important factor (Kääriäinen et al. 2018; Kokina & Blanchette 2019). According to vast amount of the literature, RPA is currently considered to be most suitable to automatize mature processes with high-volume of repetitive and routine tasks which are based on standardized rules. This leaves out processes requiring human consideration and interaction. (Willcocks et al. 2015a; Willcocks et al. 2015b; Asatiani & Penttinen 2016; Aguirre & Rodriguez 2017; Parviainen et al. 2017; Kääriäinen et al. 2018; Moffitt et al. 2018) Suitable process should also be in digital form, have structured data, and use multiple systems. On the other hand, processes with changing interfaces, paper inputs, and fragmentation (e.g. same process performed differently in different regions) are challenging for RPA. (Moffitt et al. 2018; Kääriäinen et al. 2018; Kokina & Blanchette 2019)

The above description of process' suitability for RPA brings us to the process criteria that are used to select the appropriate processes for RPA's application (Santos et al. 2019). As previously mentioned, the most defining criteria for a process found in the literature is that it needs to consist of relatively simple and repetitive rule-based tasks with little variability and low complexity (Fung 2014; Willcocks et al. 2015a; Asatiani & Penttinen 2016; Lacity & Willcocks 2016a; Aguirre & Rodriguez 2017; Hallikainen et al. 2018;

Kääriäinen et al. 2018; Moffitt et al. 2018; Cooper et al. 2019; Huang & Vasarhelyi 2019; Kokina & Blanchette 2019). Rule-based processes can be documented, resulting in lower knowledge transfer costs (Lacity & Willcocks 2016a) which in turn results in faster and easier automation (Moffitt et al. 2018). Typically, the tasks in such processes have a low requirement for cognitive actions which makes them more appealing for RPA (Asatiani & Penttinen 2016; Aguirre & Rodriguez 2017).

The simplicity is quite often combined with the condition of high volume of transactions for tasks in the process (Fung 2014; Willcocks et al. 2015a; Lacity & Willcocks 2016a; Aguirre & Rodriguez 2017; Kääriäinen et al. 2018; Moffitt et al. 2018; Penttinen et al. 2018; Huang & Vasarhelyi 2019; Kokina & Blanchette 2019). Automation is easier to justify for voluminous processes due to positive business case and, therefore, provide the best opportunity to benefit from automation (Fung 2014; Lacity & Willcocks 2016a; Moffitt et al. 2018; Kääriäinen et al. 2018). However, also processes with low volume can be candidates for RPA if the business value of those processes is high enough to justify automation (Fung 2014; Lacity & Willcocks 2016a; Hallikainen et al. 2018).

The required simplicity for the processes is highlighted in the literature with the conditions like low amount of exception handling required in the process (Fung 2014; Kääriäinen et al. 2018; Kokina & Blanchette 2019) followed by the ease of decomposing the process into unambiguous rules (Fung 2014; Moffitt et al. 2018). This is the case because the more exceptional cases a robot needs to complete, the more time is invested into testing and optimization, delaying process automation (Fung 2014). Processes with limited human interaction are typically easier to configure (Fung 2014; Kokina & Blanchette 2019), but also the processes that have human interaction, and are prone to human errors, can be good candidates for RPA (Fung 2014; Kääriäinen et al. 2018). In case the process is prone to human errors, automation can provide a superior performance (Fung 2014).

Since RPA is mainly focused on mimicking humans in mundane tasks, processes that require frequent manual effort to interact with multiple IT systems are prominent for RPA (Fung 2014; Lacity & Willcocks 2016a; Kääriäinen et al. 2018; Penttinen et al. 2018; Kokina & Blanchette 2019). Manual effort in frequently accessing multiple systems can lead to human errors, inconsistent performance, and high cost of impact, therefore, automation can be used to reduce such risks (Fung 2014; Kääriäinen et al. 2018). Important to note about IT systems related to RPA is that the user interface should remain stable, since processes in an unstable environment are prone to uncertainties and unpredictable disruptions (Fung 2014; Penttinen et al. 2018), while the back-end system architecture itself is changeable (Penttinen et al. 2018). This is specifically the case for RPA as in other BPA, the changes in user interface are not that critical, but the changes in the back-end systems are (Penttinen et al. 2018).

Related to IT is the data used and the digital nature of the candidate processes for RPA. First of all, the process needs to be executed in digital environment in order to apply a software robot to it (Lacity & Willcocks 2016a; Kääriäinen et al. 2018; Moffitt et al. 2018; Penttinen et al. 2018; Cooper et al. 2019; Huang & Vasarhelyi 2019; Kokina & Blanchette 2019). The data used in the process must be compatible with the RPA software (Kääriäinen et al. 2018; Huang & Vasarhelyi 2019) and accessible which can be limited due to e.g. confidentiality issues (Kääriäinen et al. 2018). In addition, the data used in the process should be structured (Kääriäinen et al. 2018; Moffitt et al. 2018; Huang & Vasarhelyi 2019; Kokina & Blanchette 2019).

The data is not the only aspect of the process that should be standardized. Instead, many studies conclude that the level of standardization of the process is an important aspect when choosing which process to automate (Willcocks et al. 2015a; Lacity & Willcocks 2016a; Aguirre & Rodriguez 2017; Kokina & Blanchette 2019). Moreover, the level of maturity of the process should be high (Willcocks et al. 2015a; Lacity & Willcocks 2016a; Moffitt et al. 2018; Huang & Vasarhelyi 2019). Mature processes are more predictable since they are measured, documented, stable, and their costs are known (Lacity & Willcocks 2016a) which makes automating them less risky (Moffitt et al. 2018). Closely related to maturity lies the last found criteria from the literature, the awareness of the current costs of the process (Fung 2014; Lacity & Willcocks 2016a; Hallikainen et al. 2018). Understanding current costs of processes helps to decide which process is the best candidate for automation (Fung 2014).

As can be seen, the process criteria for RPA are plenty, but there are also many processes fulfilling those criteria based on the vast amount of RPA applications found from the literature (Willcocks et al. 2015a; Lacity & Willcocks 2016a; Aguirre & Rodriguez 2017;

Suri et al. 2017; Hallikainen et al. 2018; Kääriäinen et al. 2018; Moffitt et al. 2018; Ratia et al. 2018; Cooper et al. 2019; Huang & Vasarhelyi 2019; Kokina & Blanchette 2019). Although the conditions presented above are gathered from the literature on RPA, Penttinen et al. (2018) noted that some of the criteria also applies for traditional BPA. Penttinen et al. (2018) criticize criteria such as high volume of transactions, need to access multiple systems, stable environment, and limited exception handling because these criteria do not purely apply to RPA, instead, the same criteria can apply to back-end system automation as well.

2.2.5 Previous use cases of RPA

According to Santos et al. (2019), RPA can be applied to any industry. Case studies found from the literature have applied RPA in industries such as finance (Aguirre & Rodriguez 2017; Suri et al. 2017; Kokina & Blanchette 2019), accounting (Cooper et al. 2019), IT (Suri et al. 2017), telecommunications (Lacity & Willcocks 2016a; Penttinen et al. 2018), insurance (Willcocks et al. 2015a; Kokina & Blanchette 2019), and healthcare (Ratia et al. 2018). Since RPA can be applied to basically any industry, this sub-section will focus on the types of processes RPA has been previously applied to.

RPA is mostly applied to back office processes that consist of core and support business processes of the organization (Willcocks et al. 2015a; Aguirre & Rodriguez 2017; Kääriäinen et al. 2018). This is likely due to the constant pressure for back offices to contain costs while also obtaining service excellence and improving their performance (Willcocks et al. 2015a). Back office processes are functional business processes where customer is not directly involved (Aguirre & Rodriguez 2017; Cooper et al. 2019). Such functional processes are good candidates for RPA as they typically consist of repetitive manual tasks in great volumes (Suri et al. 2017). The functional processes can include, for example, finance, procurement, human resources, and operational processes such as inventory tracking (Aguirre & Rodriguez 2017; Cooper et al. 2019).

According to a study conducted by Kääriäinen et al. (2018), covering 878 use cases of RPA, RPA is most commonly applied to tasks or short parts of a process instead of automating the entire end-to-end process. The automatable tasks an RPA robot performs inside a process typically consist of simple repetitive manual actions (Willcocks et al.

2015a; Lacity & Willcocks 2016a). Such actions can be transferring data from emails, PDFs, or spreadsheets into different IT systems (Willcocks et al. 2015a; Lacity & Willcocks 2016a; Aguirre & Rodriguez 2017; Kääriäinen et al. 2018; Moffitt et al. 2018), logging in to systems using their own credentials (Hallikainen et al. 2018), reading and sending emails (Hallikainen et al. 2018; Moffitt et al. 2018), or interpreting text, tables, and figures to extract, copy, and paste key information to fill forms (Aguirre & Rodriguez 2017; Hallikainen et al. 2018; Moffitt et al. 2018). In addition, RPA tasks can include clicking and moving a mouse, performing quality checks to various systems, and merging information from multiple systems to one (Aguirre & Rodriguez 2017; Hallikainen et al. 2018; Moffitt et al. 2018). Lastly, RPA can be used to replace system integration when transferring data between systems (Kääriäinen et al. 2018).

Since RPA is commonly applied to tasks or short parts of a process, some human intervention may be necessary to complete the process (Kääriäinen et al. 2018). According to Hallikainen et al. (2018), RPA robots are designed to work together with humans instead of replacing us. Human intervention is primarily needed when a robot gets stuck on an error (Hallikainen et al. 2018) or in a decision that requires human judgement (Leno et al. 2020). Robots that require human interaction between steps can be called attended bots, and those that do not, are called unattended bots (Leno et al. 2020). Typical use case for an attended bot is highlighted in one of the use cases presented by Penttinen et al. (2018). In the study, RPA was applied to a bidding process to perform an automatic availability check for a product. The task of availability checking was only one part of the whole process which checked the inventory status of the product. Rest of the process was left to manual operation as it required professional expertise. Even though the process was not completely automated, the employees could now better focus into tasks requiring human skills instead of manually checking IT systems for availability information of the product. (Penttinen et al. 2018) On the other hand, if the tasks are routine and all execution paths are well known, bots can be unattended, requiring no human interaction in its performance (Leno et al. 2020).

2.2.6 Difference between RPA and BPA

While evaluating which process is the best candidate for automation is important, we also need to assess if RPA is the best choice of automation to the chosen process (Kokina &

Blanchette 2019; Santos et al. 2019). This brings us to the dilemma of choosing between RPA and traditional BPA methods (Willcocks et al. 2015b; Lacity & Willcocks 2016a; Penttinen et al. 2018; van der Aalst et al. 2018). The traditional back-end system automation can be defined as “invasive automation, implemented by means of system development and/or data or application layer system integration” (Penttinen et al 2018, p. 3). Whereas RPA automation functions through the presentation layer (Willcocks et al 2015b; Lacity & Willcocks 2016) as discussed previously in section 2.2.

The selection between traditional process automation and RPA depends on the nature of the process as demonstrated in Figures 7 and 8. Figure 7 positions automation methods based on the types of cases a given process has. The processes that have a very high frequency and are highly structured are best to be automated using traditional BPA methods (Penttinen et al. 2018). As shown in Figure 8, this automation option typically requires more investments and IT expertise compared to RPA (Willcocks et al. 2015b; Lacity & Willcocks 2016a) since the system has to be developed from scratch and system integration is expensive (van der Aalst et al. 2018). The second category in Figure 7 includes processes best automated with RPA. Those processes include repetitive work that is not frequent or structured enough to justify the investments required for back-end automation. (Asatiani & Penttinen 2016; van der Aalst et al. 2018) The processes most suitable for RPA are typically owned by business operators as they require process expertise as shown in Figure 8. Since RPA does not require coding skills to configure the robot and it can be built on top of existing systems without changing them, using RPA as an automation method does not require as many investments as back-end automation does. (Willcocks et al. 2015b; Lacity & Willcocks 2016a; Penttinen et al. 2018) Lastly, in the third section of Figure 7, there is the work that is irregular and exceptional enough that automation is not possible or financially beneficial with the means of neither RPA nor back-end automation (Asatiani & Penttinen 2016; van der Aalst et al. 2018).

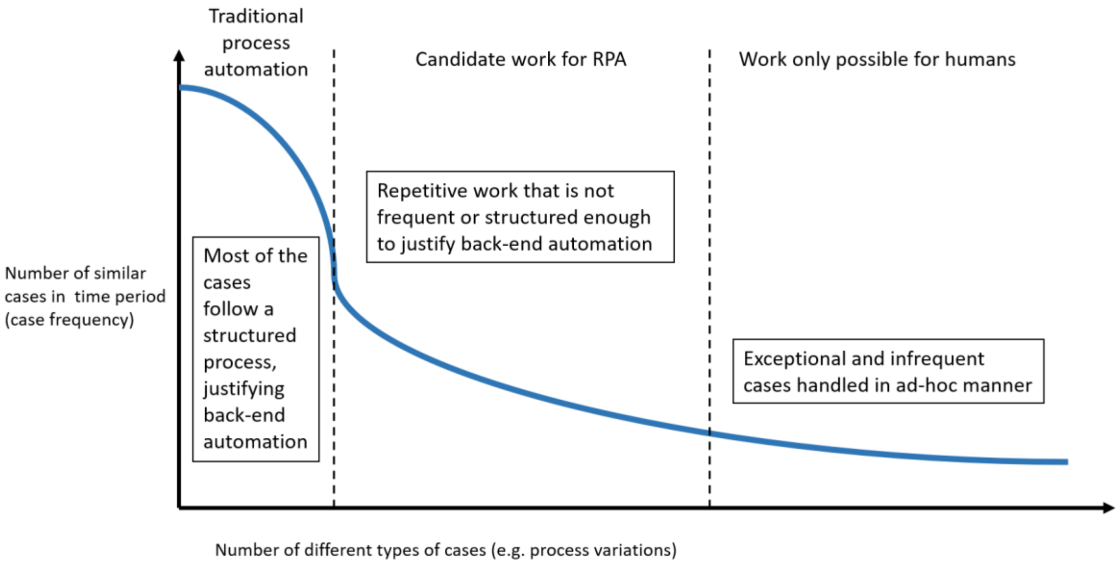

Figure 7. The positioning of automation methods. (Adapted from Asatiani & Penttinen 2016; van der Aalst et al. 2018)

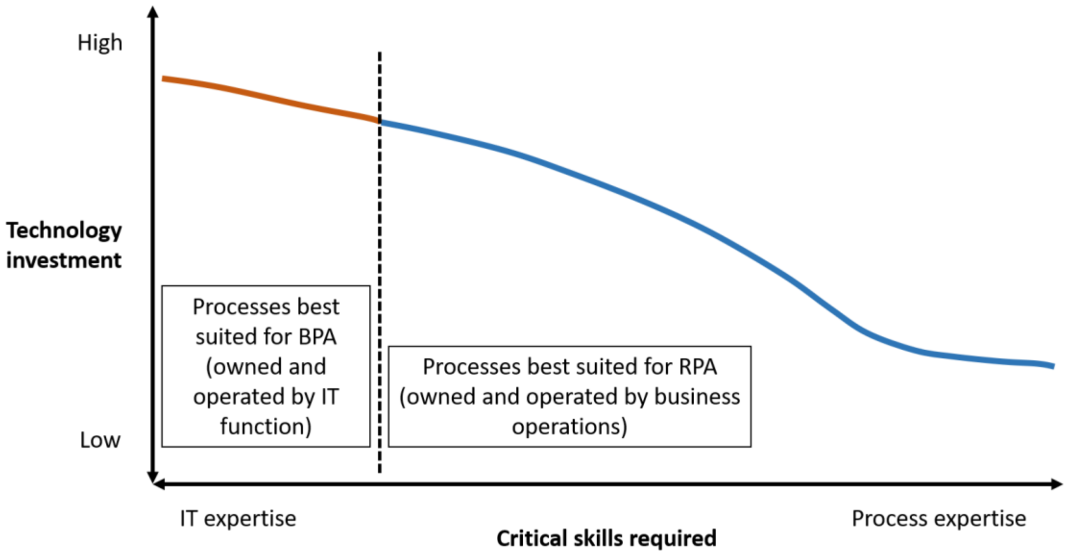

Figure 8. RPA complementing BPA. (Adapted from Lacity & Willcocks 2016a)

In addition to the volume and types of the cases; the amount of investments; and the required skill set, Penttinen et al. (2018) discovered additional process characteristics to consider when deciding which automation method to use. As shown in Table 1, one should consider the stability of both user interfaces and systems, the interfaces between existing systems, as well as the number of systems, time criticality of the automation effort, and the permanence of the process. As previously mentioned, RPA works on top of existing IT systems using the presentation layer, also known as the user interface

(Willcocks et al. 2015b). This means that changes made to the underlying systems are not a problem for RPA, instead, changes in the user interface are a problem as the robots may need to be re-configured (Kääriäinen et al. 2018; Penttinen et al. 2018). Since RPA solutions are faster to develop compared to traditional back-end automation, the most time critical automation efforts should consider RPA as the primary option, however, if the process is permanent, traditional automation can provide a better end result as it changes the underlying process while RPA only attempts to make the existing process more efficient (Willcocks et al. 2015b; Penttinen et al. 2018). Such dependency on the existing IT systems means that RPA complements traditional automation methods (Willcocks et al. 2015b), but at the same the dependency on existing IT is one of the weaknesses of RPA solutions as the results of RPA rely on outcomes of the existing IT systems (Penttinen et al. 2018).

Table 1. Selection characteristics for different automation methods. (Adapted from Penttinen et al. 2018)

Criteria	**In favour of RPA**	**In favour of traditional BPA**
Number of IT systems	Multiple	One
Task volume of a process	Moderate to high	Very high
Stability of back-end system architecture	Changing	Stable
Stability of user interfaces	Stable	Changing
Time to market	Time critical	Not time critical
Permanence of a process	Temporary	Permanent
IT resource allocation	Low	Medium to high
Interfaces between systems	No interfaces between systems	Systems have existing APIs

2.2.7 Implementation of RPA

Each implementation project starts with process analysis and selection phase to identify the most suitable processes for RPA (Lacity & Willcocks 2016a; Suri et al. 2017; Hallikainen et al. 2018; Kääriäinen et al. 2018; Moffitt et al. 2018; Huang & Vasarhelyi 2019; Jimenez-Ramirez et al. 2019; Kokina & Blanchette 2019). This step requires the involvement of a technical expert of RPA and an expert of the process substance (Kääriäinen et al. 2018). In addition, it is important to create a baseline of the current process performance to be able to track and realize the effects of automation (Hallikainen et al. 2018). The effect of automation and the current process performance is used to create business cases of different processes around the RPA implementation. The basis of the business case is based on the expected benefits gained from RPA, as discussed in section 2.2.1, and it needs to be approved by management before a pilot project is started. (Suri et al. 2017; Kääriäinen et al. 2018) Suri et al. (2017) also identified some difficulties in developing the business cases. The difficulties can be divided into financial and non-financial categories. The financial factors consist of the difficulty of estimating the gained benefits from RPA and the cost of implementation while non-financial factors concern difficulties in governance, operational disruption, and employee acceptance. (Suri et al. 2017) After the business cases are ready, the processes are scored based on the business cases, and a decision is made whether RPA is the automation method that would add most value to the process (Lacity & Willcocks 2016a; Moffitt et al. 2018; Kokina & Blanchette 2019). The process scoring can be made easier by using a list of criteria for RPA (Jimenez-Ramirez et al. 2019; Santos et al. 2019) as discussed before in sub-sections 2.2.4 and 2.2.6. During business case evaluation it is important to involve people with process, IT, and technical RPA expertise as knowledge in both of these fields is essential (Lacity & Willcocks 2016a; Kääriäinen et al. 2018).

Along with the business case creation, in order to get better knowledge of what actions need to be performed in the process, an 'as-is' process is documented into a flowchart together with a future state of the process (Suri et al. 2017; Moffitt et al. 2018; Kääriäinen et al. 2018; Kokina & Blanchette 2019). Documenting the process in detail is necessary in development of the robots, for example to understand process variations (Hallikainen et al. 2018; Huang & Vasarhelyi 2019; Kokina & Blanchette 2019), but it may also reveal that some pre-automation process improvement is needed as such improvements can improve RPA performance and reduce exceptions in the process (Lacity & Willcocks 2016a; Moffitt et al. 2018; Kokina & Blanchette 2019). In addition, process improvement may be necessary to standardize and structure the data and data flows used in the process or to create digital inputs to the process (Moffitt et al. 2018; Kääriäinen et al. 2018; Huang & Vasarhelyi 2019; Jimenez-Ramirez et al. 2019). One way to document and discover processes with automation potential is to monitor work in non-invasive manner (invisible for the user) using a monitoring software as described by Jimenez-Ramirez et al. (2019). Their method recorded the screen, mouse, and key events performed by staff and transformed them into standardized event logs. The event logs were then analysed with the help of process mining to automatically discover a process model that was used to configure the RPA robot. (Jimenez-Ramirez et al. 2019)

The next step in the implementation project is the development of RPA. The initial RPA implementation typically involves performing a proof-of-concept inform of a small pilot project to demonstrate what are the capabilities of RPA for the selected process. (Lacity & Willcocks 2016a; Suri et al. 2017; Moffitt et al. 2018; Hallikainen et al. 2018; Huang & Vasarhelyi 2019; Kokina & Blanchette 2019) When RPA is first introduced to an organization, the pilot is done before any software licenses are bought. The selected process should be simple yet important with enough improvement potential to showcase the potential benefits of RPA through quick-wins. (Lacity & Willcocks 2016a; Hallikainen et al. 2018; Kokina & Blanchette 2019) These quick-win projects provide support to achieve widespread acceptance of RPA in an organization during the initial adoption of RPA (Lacity & Willcocks 2016a; Kokina & Blanchette 2019). Pilot can also be done to test process complexity in order to reduce the risks associated with RPA's implementation (Huang & Vasarhelyi 2019) and to test whether RPA is the correct method for automation (Lacity & Willcocks 2016a; Kokina & Blanchette 2019). However, when RPA is first adopted to organizations, the organizations first select their preferred RPA provider and consulting partner to perform the pilot (Hallikainen et al. 2018; Huang & Vasarhelyi 2019; Kokina & Blanchette 2019) although, sometimes a pilot can be performed by multiple vendors and the final decision is done afterwards (Lacity & Willcocks 2016a).

According to Willcocks et al. (2015) and Moffitt et al. (2018), RPA can be seen as a quick-fix tool, but it should be treated as an enterprise-led solution that is systematically applied. Therefore, it is important to establish organizational structure for RPA governance and oversight at the same time with RPA's implementation. The governance of RPA can be integrated into organizations' existing continual improvement framework, but often, organisations develop a Robotic Operating Model which is introduced through a centralized governance such as Center of Excellence (*hereinafter* CoE). (Kokina & Blanchette 2019) The CoE gathers together common modules for RPA to establish a centralized process library. The common modules consist of RPA tasks that function the same way in any situation they are used in such as writing a log. With the help of a centralized process library, it is not required to create an RPA robot from the scratch every time for these use cases. (Hallikainen et al. 2018) Kokina & Blanchette (2019) also mentioned that by dividing automated processes into smaller parts in terms of coding (i.e. common modules), reduces the risks associated with bot breakage and improves the flexibility of the bots. The CoE should also be used to train and communicate employees regarding RPA, starting from the very first pilot (Lacity & Willcocks 2016a; Hallikainen et al. 2018). In addition to this, the CoE can be used to provide alternative career paths that retain the best talent by developing new skillsets regarding RPA (Suri et al. 2017). New information about RPA can also be internally distributed through a website dedicated to RPA as reported by Hallikainen et al. (2018).

During robot development it is important to ensure good collaboration of people in business, IT, and RPA experts straight from the beginning as expertise in these fields is vital to configure a robot (Lacity & Willcocks 2016a; Hallikainen et al. 2018; Moffitt et al 2018; Kokina & Blanchette 2019). It is also seen important to develop a responsibility relationship chart to clarify the roles of business and IT groups during robot implementation (Suri et al. 2017). The development process itself should be seen as a continuous improvement process (Hallikainen et al. 2018; Huang & Vasarhelyi 2019). New tasks should only be automated after the previous ones' performance is on satisfactory level (Hallikainen et al. 2018). Since RPA brings many safety concerns, establishing preventative controls for internal and external parties as well as profiling bots' risk levels is important in order to manage these risks (Kokina & Blanchette 2019; Kääriäinen et al. 2018). In addition, poor performance should trigger a new analysis and design phase of bot development (Huang & Vasarhelyi 2019). Typically, the poor performance of robots is associated with some of the challenges of RPA which are discussed on sub-section 2.2.3. For example, discovering all of the unpredictable and exceptional cases in processes is seen as one of the most challenging aspects in robot development (Hallikainen et al. 2018; Kokina & Blanchette 2019). Other challenges witnessed by Hallikainen et al. (2018) included the robot working too fast for other systems and that the connection between systems were problematic for RPA.

After the robots are developed and deployed into action, the operation and monitoring phase begins. This phase focuses on keeping track of RPA performance, training RPA to personnel, and applying RPA to new processes in order to spread RPA inside the organization (Huang & Vasarhelyi 2019; Kokina & Blanchette 2019). As mentioned before in this section, a baseline of current process performance should be created to be able to monitor the results of RPA (Hallikainen et al. 2018; Kääriäinen et al. 2018). The same way, it is important to keep track on how the robots are performing after they are deployed to processes (Kääriäinen et al. 2018; Cooper et al. 2019; Huang & Vasarhelyi 2019; Kokina & Blanchette 2019). The assessment of robot performance is typically focused on detecting errors and exceptions, robot up and down times, and comparison of performance to manual work (Cooper et al. 2019; Huang & Vasarhelyi 2019; Kokina & Blanchette 2019). KPIs present in the literature include ROI, which is the most used one, but should not be the only one considered (Kokina & Blanchette 2019). Other KPIs to be considered are shown in Table 2. Many of the RPA software include embedded dashboards to monitor such KPIs (Cooper et al. 2019), but Kokina & Blanchette (2019) also suggested that process mining could help especially with monitoring RPA performance.

Table 2. KPIs used to monitor RPA performance.

KPI	**Reference**
Return on investment (ROI)	Cooper et al. 2019; Huang & Vasarhelyi 2019; Kokina & Blanchette 2019
Human labour hours saved	Moffitt et al. 2018; Kokina & Blanchette 2019
Error rate	Cooper et al. 2019; Huang & Vasarhelyi 2019; Kokina & Blanchette 2019
Cost reduction	Kokina & Blanchette 2019
Robot up, down, and maintenance times	Cooper et al. 2019
Amount of bot breakages	Cooper et al. 2019
Number of exceptions (with reasons behind them)	Cooper et al. 2019
Processing time per case	Cooper et al. 2019
Conformance checking (comparing robot's work results to manual human work results)	Huang & Vasarhelyi 2019
Straight-through processing rate	Kokina & Blanchette 2019

In addition to monitoring process performance, the operation and monitoring phase should include continuous training for employees (especially for change agents) regarding RPA, and creating some additional changes such as upgrading the organization's server and firewall policies to match with RPA's requirements (Hallikainen et al. 2018). Lastly, assigning a robot to do human work may generate cultural pressure in form of confusion and fear among employees (Willcocks et al. 2015; Kääriäinen et al. 2018). It is the role of maintenance phase to manage such changes in the environment. RPA robot should be seen as a part of the service team's resources instead of an IT tool, and management should have strong and active communication about RPA. This type of approach eases the cultural strains occurred from replacing human work with automation. (Hallikainen et al. 2018; Kääriäinen et al. 2018)

2.3 Process mining

This section introduces process mining, explains how process mining tools can be used for analysing processes, and what they need in order to work. Different types of process mining use cases are presented to showcase how process mining links to BPM. In addition, some weaknesses and considerations of using process mining are discussed briefly along this section.

Process mining is an emerging research area and a relatively young field of process management that forms a bridge between data and process science (van der Aalst 2016; Gameni & Amyot 2020). PM is a family of process analysis methods that combine machine learning and data mining, adding a process perspective to them by taking use of process models and observations of business processes' real behaviour (van der Aalst et al. 2012; van der Aalst 2016; Di Francescomarino et al. 2018; Dumas et al. 2018; García-Bañuelos et al. 2018). In order to analyse business processes with their real behaviour, PM extracts event data from information systems such as ERP, CRM, BPM, or SCM systems that contain evidence-based insights about the process. (van der Aalst 2003; de Leoni et al. 2016; Ghasemi & Amyot 2020).

PM is defined as a combination of model-based and data-centric process analysis techniques used to analyse the performance and conformance of business processes based on information gathered from event logs produced during process execution (de Leoni et al. 2016; van der Aalst 2016; Dumas et al. 2018). The goal of PM is to extract process-related information from event logs in order to discover, monitor and improve real processes (van der Aalst et al. 2007; van der Aalst 2016). The techniques of PM allow users to see how the process is executed in reality, check whether regulations are followed, and gain insight into process performance aspects such as bottlenecks (de Leoni et al. 2016; Dumas et al. 2018). However, it is important to note that only the events logged are monitored making some interactions invisible to the analysis of PM. In addition, systems may force workers to work in a certain way which may cause the discovered process to reflect the system instead of the organization. (van der Aalst et al. 2007)

2.3.1 Process mining types

Process mining activities are generally divided into three types: discovery, conformance, and enhancement (van der Aalst 2011; Ghasemi & Amyot 2016). These types can be seen from Figure 9 which shows their positioning within PM and their linkage to the real world (van der Aalst 2016). The first and most applied PM type is *process discovery* (Rojas et al. 2016; Maita et al. 2018; Kerremans et al. 2020). Discovery focuses on building a model of the analysed process without relying on existing process models. Instead, it assumes that the system's way of working is unknown and builds a process model based on the data gathered in event logs using different types of algorithms. (van der Aalst et al. 2007; Breuker et al. 2016; van der Aalst 2016; Dumas et al. 2018; Leemans et al. 2018; Reinkemeyer 2020) As can be seen from Figure 10, the only input for discovery is an event log which results to a process model as the output.

The second type of PM is *conformance*. Conformance compares an existing process model with the observed behaviour from event logs, studying the differences between the model and reality. Therefore, its goal is to detect inconsistencies between the activities in the process model and the real observations in the event log. (Rozinat & van der Aalst 2008; Breuker et al. 2016; van der Aalst 2016; Dumas et al. 2018; García-Bañuelos et al. 2018; Leemans et al. 2018; Reinkemeyer 2020) As Figure 10 illustrates, conformance takes both an event log and a process model as input, producing conformance diagnostics as the output.

The third type of PM is *enhancement* where the goal is to improve or change an existing process model. Process model can be improved with additional information about the actual process acquired from an event log. The improved model can, for example, include information about the process bottlenecks that are slowing down the process. (Breuker et al. 2016; van der Aalst 2016; Dumas et al. 2018) Enhancement creates a new (enhanced) process model as the output from an event log and an existing process model as shown in Figure 10.

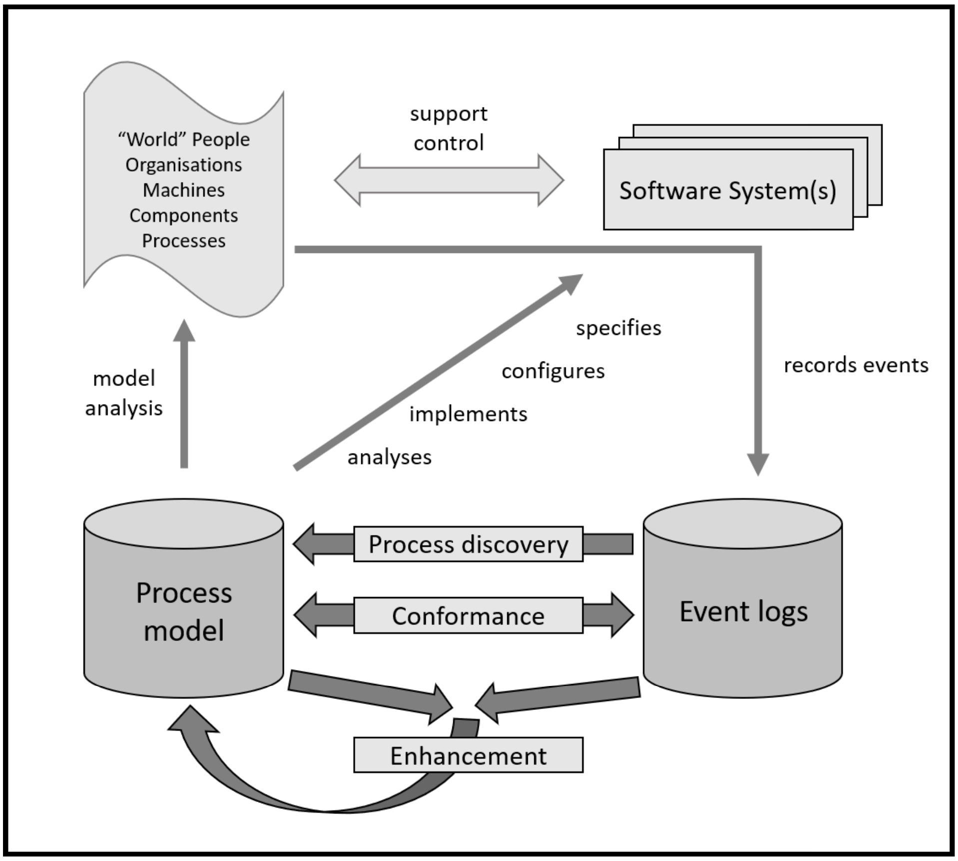

Figure 9. Three main types of process mining: discovery, conformance, and enhancement (Adapted from van der Aalst 2016).

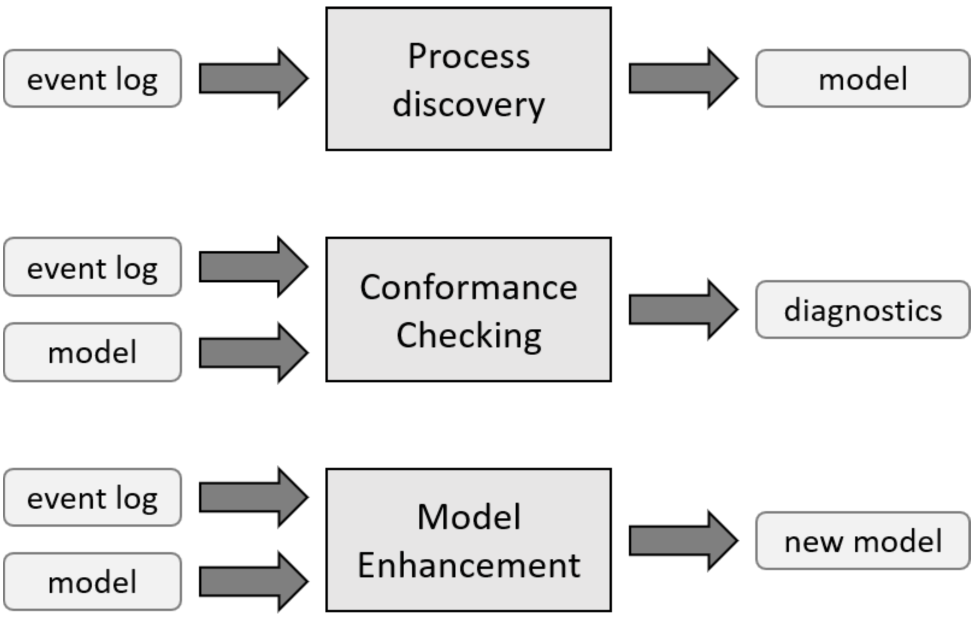

Figure 10. The inputs and outputs for three process mining types (Adapted from van der Aalst et al. 2012)

Traditionally, PM techniques have been *reactive* rather than *predictive*. Lately, predictive PM techniques have started to be increasingly developed to extend the PM analysis to predict the outcome of uncompleted cases of a process at runtime. The predictions are made by evaluating different metrics or process indicators regarding the efficiency and effectiveness of the process or its compliance with regulations. The new forward-looking techniques allow users to know in advance about violations, deviances, and delays in process execution, making it possible to prevent undesirable outcomes of a process resulting to e.g. money loss. (Maggi et al. 2014; Di Francescomarino et al. 2018; Márquez-Chamorro et al. 2018)

2.3.2 Event logs

As explained above, event logs are used in all of the PM types, making them the primary input for PM (van der Aalst 2007; García-Bañuelos et al. 2018). Therefore, it is vital to understand what exactly it is and what it contains. *Event log* is a collection of *activities* that have been executed in a business process (a.k.a. a *case*). Cases are the *process instances* (e.g. customer orders) that are handled in the process. Each case consists of multiple activities that can be executions of work items, tasks, or other relevant activities in a process that are recorded into enterprise systems such as ERP, CRM, SCM, and PLM systems. (van der Aalst et al. 2007; de Leoni et al. 2016; Rojas et al. 2016; van der Aalst 2016; Di Francescomarino et al. 2018; Dumas et al. 2018; García-Bañuelos et al. 2018; Leemans et al. 2018; Reinkemeyer 2020) In event logs, these activities are commonly called *events*. Each event is always referring to an individual case and exactly one type of an activity. Event logs also contain timestamps indicating the time of occurrence for the given event. (van der Aalst 2007; Rozinat & van der Aalst 2008; Breuker et al. 2016; Leemans et al. 2018)

The minimum requirement for PM is that an event log contains a unique case ID, an event ID (a.k.a. a process step or an event type), and a timestamp for each event listed in the log. An example of such a log is shown in Table 3 below. In addition to these requirements, event logs typically contain other data attributes such as performer or cost of the task (van der Aalst et al. 2007; Rozinat & van der Aalst 2008; García-Bañuelos et al. 2018). It is also important to note that the information used to create event logs is typically scattered around various sources in unstructured format which requires any PM effort to first extract the data from these sources into usable format (Rojas et al. 2016; van der Aalst 2016; Dumas et al. 2018). Therefore, data needs to be merged, extracted, and filtered before it is transformed into an event log and used for PM. Since the extracted data should be based on questions rather than data availability, scoping the data accordingly to each PM use case is very important (van der Aalst et al. 2003; van der Aalst 2016).

Table 3. An example of an event log containing minimum information required for process mining (Adapted from Reinkemeyer 2020).

Case ID	Event	Timestamp
001	Ticket creation	Feb 1, 15:00
001	Ticket screening	Feb 1, 15:18
001	Simple repair	Feb 8, 10:34
001	Ticket clearing	Feb 8, 14:56
002	Ticket creation	Feb 1, 15:55
002	Ticket screening	Feb 1, 15:59
002	Complex repair	Feb 2, 09:32
002	Ticket clearing	Feb 6, 11:25
003	…	Feb 2, 10:11

2.3.3 Process mining use cases

As the process mining types discovered in sub-section 2.3.1 may suggest, there are multiple use cases for process mining. Based on a survey conducted by Gartner to process mining vendors shown in Figure 11, traditionally the most commonly applied use case for PM has been improving business processes. However, Gartner estimates that other use case areas are starting to become more common during 2020 as PM is being adopted more widely in businesses (see Figure 11). For example, supporting process automation and digital transformation with PM is estimated to increase. (Kerremans et al. 2020)

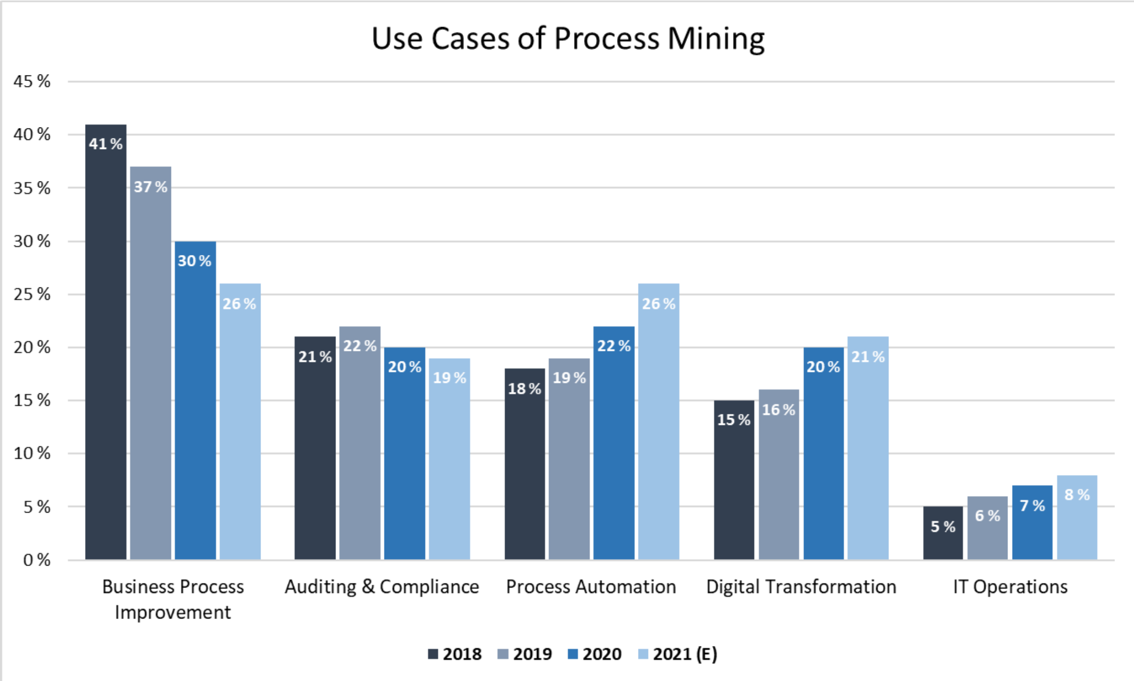

Figure 11. Process mining use cases based on market study conducted by Gartner (Adapted from Kerremans et al. 2020).

PM supports business process improvements by allowing businesses to have a true transparent view on their processes. This is a vast improvement to the traditional methods of process mapping workshops, using internal and external auditors and consultants, or conducting interviews to individuals working the process. Such methods are typically local and only conducted once which makes understanding ever-changing, complex end-to-end processes difficult. However, with PM, processes can be analyzed with the support of real-time facts of the process which makes identifying problem root causes easier so that they can be removed. PM is also used to control and monitor the process with meaningful KPIs which are also useful when the results of the improvement activities are reported across the organizations. (Ghasemi & Amyot 2016; Rojas et al. 2016; Márquez-Chamorro et al. 2018; Buhrmann 2020; El-Wafi 2020; Henriques 2020; Jansen 2020; Lechner 2020; Lillig 2020; Nguyen 2020; Rowlson 2020; Schukat 2020)

As can be expected based on the conformance PM type, one major use case for PM is compliance and auditing. PM is very helpful for auditing as it is able to compare the agreed way of doing things to the way things are actually done based on the data in event logs. Compliance monitoring can be applied, for example to see how well service level agreements or regulations are followed or to spot any incidents of maverick purchasing.

This is possible with the new level of objectivity and transparency provided by PM. (Maggi et al. 2014; Ghasemi & Amyot 2016; García-Bañuelos et al. 2018; Márquez-Chamorro et al. 2018; Boenner 2020; Henriques 2020)

Business performance can also be improved through process automation as discussed in section 2.2. PM is often used to support process automation projects by identifying candidate processes for automation. Such candidates for automation can, for example, be process exceptions discovered by PM. Another common way to use PM for automation initiatives is to measure the amount of manual activities in the process and calculate automation rate KPIs. Such KPIs give organizations an overview on how well they are able to utilize automation possibilities in their processes. In addition, the performance of various automations can be monitored and controlled with PM to ensure that robots are working as expected. (Boenner 2020; Buhrmann 2020; El-Wafi 2020; Henriques 2020; Lechner 2020; Nguyen 2020; Rowlson 2020)

Implementation of PM starts off by extracting data and creating data models of that data. This on another hand creates a positive side effect of cleaning up organization's master data in the source systems to get meaningful analysis. The focus on data quality, consistency, and transparency also helps organizations in their digital transformation. (Boenner 2020; Henriques 2020; Jansen 2020; Lechner 2020; Nguyen 2020) Lechner (2020) even suggested that PM could become a tool for digital transformation in the future. In addition to the above use cases, Reindler (2020) has also applied PM to help them with product development by discovering the ways their products are used. This allows them to develop their products in a more user-friendly fashion.

2.4 Literature synthesis

The literature review of this thesis covers three main topics: management of business processes, robotic process automation, and process mining. The literature supports this research by providing an understanding of these topics. Furthermore, the literature shows that these topics are connected to each other and that their inter-connection still requires more research as there are currently very few studies that combine the use of RPA and PM to help achieve BPM targets.

Based on the literature review, research questions (1) and (2) can be partly answered. Research question (1) focuses on discovering the benefits of using RPA. The benefits of RPA found from the literature were introduced in sub-section 2.2.1. These benefits can be divided into quantitative and qualitative benefits.

Quantitative benefits:

- Cost savings from salary
- Cost savings from increased productivity
- Fast return on investment (especially compared to traditional BPA)
- Savings from reduced amount of errors

Qualitative benefits:

- Improved employee satisfaction from enriched work tasks
- Improved customer satisfaction due to less errors and faster processing times
- Improved flexibility as RPA can be adjusted based on demand
- Improved process standardization due to focus on processes

As explained in sub-section 2.2.1, some of the above benefits can result in both quantitative and qualitative benefits. For example, the reduction in human errors can be seen as cost savings while it also improves customer satisfaction and process quality.

Research question (2) focuses on exploring the pre-requisites of implementing RPA. Pre-requisites can be seen to comprise of disadvantages, challenges, and process criteria of RPA covered in sub-sections 2.2.2, 2.2.3, and 2.2.4, respectively. Based on these findings, the following pre-requisites for implementing RPA can be found:

Pre-requisites for the process:

- High volume of simple, repetitive rule-based tasks
- Functions in digital environment with structured data, preferably in multiple IT systems
- Standardized process

Pre-requisites for development:

- Strategic targets for RPA
- Communication and education about RPA to employees to make RPA seem less threatening and better understood
- Clear responsibilities for employees across the organization
- Detailed process definition that takes all process variants into account

- Identifying and selecting the correct processes for automation

In addition to the above pre-requisites, there are some aspects that are not strict requirements, but still something to consider when applying RPA. Such aspects are, for example: data privacy and security, robot supervision, and understanding the fact that RPA might be only a temporary fix. Furthermore, a perception made during the literature review was that there are quite a few less studies conducted on the disadvantages and challenges of RPA compared to the benefits associated with RPA. This may be due to the fact that RPA is a new area of research.

2.4.1 RPA lifecycle

In addition, the literature review revealed that even though there are multiple case studies made on RPA, there is a lack of a general framework for applying RPA. For this reason, an RPA lifecycle (Figure 12), which was inspired by the BPM lifecycle (see Figure 2 in section 2.1) presented by Dumas et al. (2018), is introduced based on the many case studies presented in this thesis.

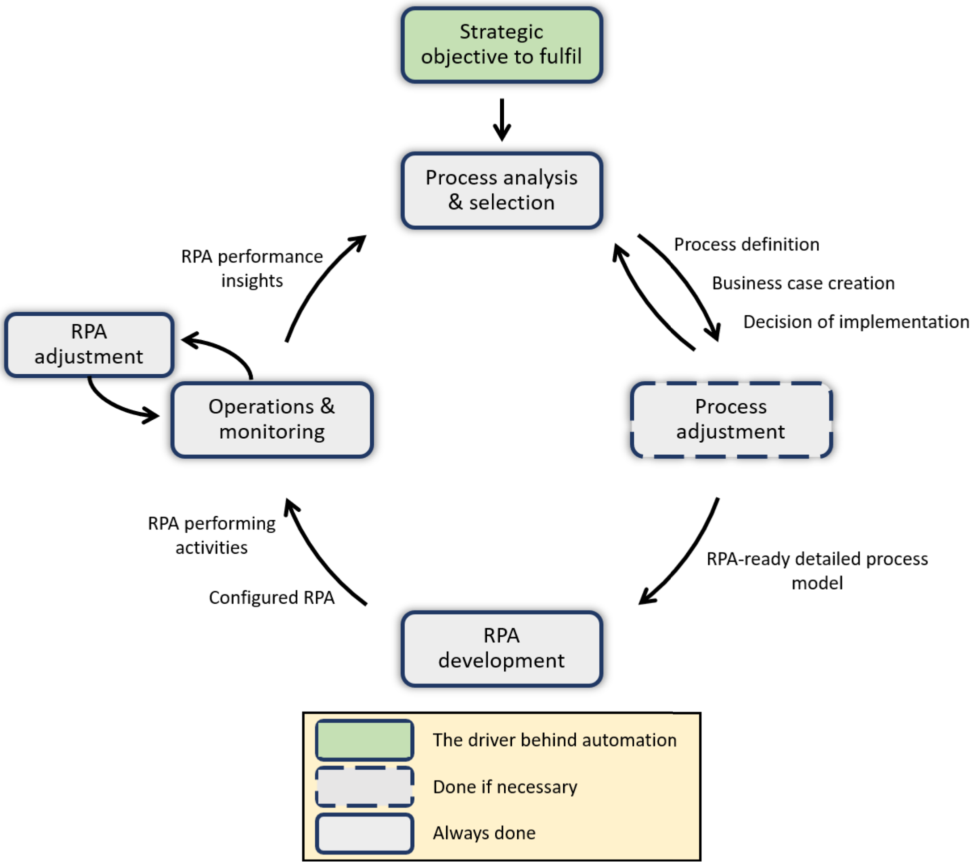

Figure 12. RPA lifecycle based on literature.

The RPA lifecycle begins from the need to fulfil some strategic objective of the organization. The focus on strategic targets was found to be critical for success when performing any activities of BPM (Hung 2006; Trkman 2010; van der Aalst et al. 2016; Meidan et al. 2017; Dumas et al. 2018). Since RPA can be seen as one of the many ways of improving business processes (Hung 2006; Ko et al. 2009; Rahimi et al. 2016; van der Aalst et al. 2016; Penttinen et al. 2018; v Kokina & Blanchette 2019; Santos et al. 2019), strategic objective should be a starting point and key focus area for applying RPA, too. The focus on strategic targets also guides organizations to focus on the most important automation candidates. (Willcocks et al. 2015b; Moffitt et al. 2018; Santos et al. 2019)

The automation candidates are evaluated during 'Process analysis & selection' phase. As common in the case studies presented in sub-section 2.2.7, the first task is to create business cases of different candidates to examine which of them is the most effective for fulfilling the strategic objective (Lacity & Willcocks 2016a; Suri et al. 2017; Hallikainen et al. 2018; Kääriäinen et al. 2018; Moffitt et al. 2018; Kokina & Blanchette 2019). During business case creation processes are defined. The process definition must be made on a very detailed level so that it is usable for RPA. Based on the process mining types discussed in sub-section 2.3.1, PM can potentially be very useful to speed up the task of process definition and to calculate effects of each business case (Rojas et al. 2016; Maita et al. 2018; Jimenez-Ramirez et al. 2019; Kerremans et al. 2020; Kokina & Blanchette 2019). Based on this analysis, the most prominent case for automation is selected and a decision of implementation is made.

The next step after the decision to implement RPA is to do potential pre-automation process adjustment. As mentioned in sub-section 2.2.7, documenting the 'as-is' process may reveal a need for process redesign that help to standardize the process and improve the effectivity of the automation (Lacity & Willcocks 2016a; Moffitt et al. 2018; Kääriäinen et al. 2018; Huang & Vasarhelyi 2019; Jimenez-Ramirez et al. 2019). It is important to improve processes before automating them as automating a faulty process will only create mistakes faster (Hammer & Champy 1995; Trkman 2010; Ratia et al. 2018). Pre-automation process adjustment may also be necessary as the organization's processes may not in reality be as standardized as the organization had initially thought (Suri et al. 2017; Kokina & Blanchette 2019).

After ensuring that the process is suitable for RPA, the development phase itself can start according to the detailed process model received from prior phases. During development, organizations should also set up governance for RPA which enables scaling the RPA in the future (Willcocks et al. 2015; Lacity & Willcocks 2016a; Hallikainen et al. 2018; Moffitt et al. 2018; Kokina & Blanchette 2019). Another important aspect for RPA’s development is to set clear responsibilities for people and to include people from IT and business into development (Lacity & Willcocks 2016a; Hallikainen et al. 2018; Moffitt et al 2018; Kokina & Blanchette 2019). The development phase should include testing to ensure that all possible exceptions are covered by the robot. In addition, communication of RPA to the organization is seen important as employees can initially be afraid of the robots performing activities they once did (Lacity & Willcocks 2016a; Hallikainen et al. 2018).

Once the RPA is configured and performing activities, it needs to be managed and controlled, and people need to be trained for RPA (Huang & Vasarhelyi 2019; Kokina & Blanchette 2019). This is the purpose of ‘Operations & monitoring’ phase. Organizations need to ensure that the robot is actually doing what is expected of it. Changes to the robot’s performance may be caused, for example, by small changes in the process or in the customers’ behavior. (Kääriäinen et al. 2018; Cooper et al. 2019; Huang & Vasarhelyi 2019; Kokina & Blanchette 2019) Such minor changes can be handled by adjusting RPA. However, if the RPA or the process requires larger changes (e.g. changes in the IT system), the lifecycle should move forward to ‘Process analysis and selection’ phase as it is likely that some of the requirements have changed. In addition to monitoring the performance of current robots, organizations should look for new automation opportunities to continually improve their performance (Huang & Vasarhelyi 2019; Kokina & Blanchette 2019). Each new automation will obviously trigger another lifecycle of RPA.

The literature review partly answers research questions (1) and (2). However, as RPA is a new research area and there is still a lack of literature on the subject, these questions will be reviewed again in later sections. The results of the literature review will be used to formulate interview questions that will be used to conduct interviews on people with professional experience on RPA and PM. The RPA lifecycle introduced based on the literature review integrates RPA as a part of BPM.

Businesses need to focus on improving processes in order to be able answer the ever-changing customer needs and to win their competitors. As is clear from Figure 11 in sub-section 2.3.3, PM has been mainly used for this same reason, to improve business processes. There is a lack of research on how PM and RPA can be used together within BPM to strive for excellence in performance. This is another question that the rest of this study aims to reveal while answering research question (3).

3 RESEARCH METHODS AND MATERIALS

This research is conducted as a qualitative interview research. The research data is composed of previous literature and semi-structured interviews. The goal of this research is to clarify what are the benefits and pre-requisites of implementing RPA, and how could process mining influence the efficiency of RPA's utilisation. Since the research topic is quite new and weakly covered in the prior scientific literature, qualitative interview research method was chosen to discover and understand the topic deeper as the results are not easily measurable by an experiment (Eriksson & Kovalainen 2008; Metsämuuronen 2011; Saunders et al. 2016).

According to Daniels & Cannice (2004), qualitative interview research is a study where data and findings are based on direct conversation between the researcher and the respondents. In this study, the conversation mentioned above was carried out as semi-structured interviews. In semi-structured interviews the researcher has key interview questions or themes listed as an interview guide, but their use may vary from interview to another. For example, the questions may not be always asked in the same order and some questions may be not asked or new ones may be introduced based on the interviews. (Bryman & Bell 2007; Myers 2013; Saunders et al. 2016)

The research methodology of this thesis can be seen in Figure 13. After a background study was conducted, gaps in the current research identified, and initial research questions were defined, the research method was selected. Based on the research method selected, the study began with a literature review. The literature review focused on gathering knowledge about the current state of RPA and PM, as well as, studying BPM to give background to these two technologies and their place in general business process development. Findings from the literature review were used to build understanding of these subjects and to provide a basis for the interview questions to be used in the empirical study. In addition, findings from the literature review were used to categorize the interview results.

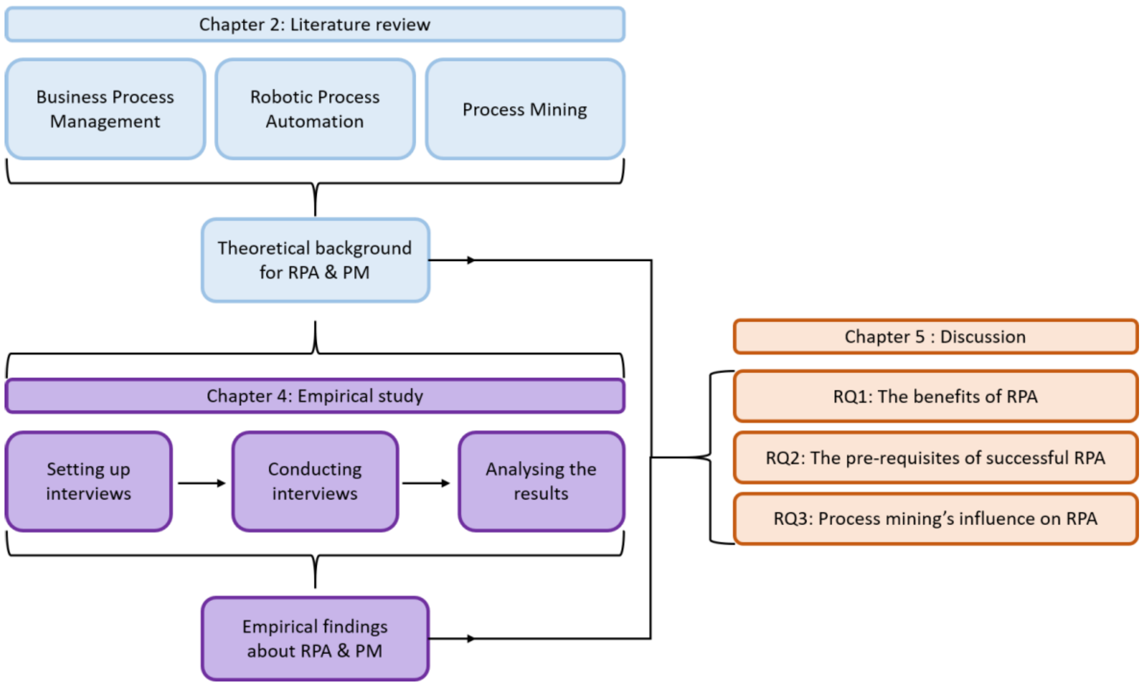

Figure 13. Research methodology of the thesis.

During the literature review, interviews were set up to gather data. Setting up the interviews included looking for potential interviewees and scheduling times for interviews. Suitable interviewees were searched online. The interviewee had to have experience on either RPA or PM, but preferably both of the topics. Some challenges emerged when it came to the experience of the interviewee on both RPA and PM, as can be seen from Table 4 which lists the interviewees' experience on RPA and PM. Some of the interviewees had vast knowledge about RPA with only little knowledge about PM and vice versa. However, some of the interviewees had a lot of experience with both technologies. Since both of these technologies are relatively new, a person with even two years of experience is assumed to have good knowledge about RPA and PM in this study. Although, some of the interviewees had less than a year of experience on RPA and PM, they had more experience in the fields of process management and data science and were able to provide great insights on RPA and PM from that viewpoint.

Table 4. Experience in RPA and process mining of each interviewee.

Interviewed person	**RPA experience**	**PM experience**
Interviewee A	Six years of working experience	Knowledge based on demos, no hands-on experience

Interviewee B	Four to three years of experience on usage, management, sales, implementation, and applying	About five years of experience on usage, management, sales, implementation, and applying
Interviewee C	About two years of experience with domestic and multinational customers	Experience based on light PM tools of the RPA software, no experience on pure PM tools
Interviewee D	One year of experience	No experience
Interviewee E	Demo experience, no technical know-how	Has used multiple PM software Limited to one process
Interviewee F	Around two years of experience	Couple of months in experience from a pilot project
Interviewee G	About one year of experience	About one year of experience
Interviewee H	One year of experience	Seven months of experience
Interviewee I	Three years of experience	18 months of experience
Interviewee J	Deep experience, involved in setting up a CoE	Experience from pilots Understands use cases and challenges.

The questions used in the interviews were formed based on the findings of the literature review and divided into according topics (BPM, RPA, and PM). In addition, there were some generic questions about the interviewee's background and some additional ones that came up during the interviews. The list of interview questions can be found in Appendix 1, where the questions written in bolded text were asked in some form in every interview, but those that are not bolded may have been asked or may not have been asked based on the interview. In total, there were 21 questions out of which eight were asked in every interview.

The interviews were conducted between late April and early June using the semi-structured interview methods as discussed above. In total, nine interviews were conducted. The conducted interviews were single person interviews with the exclusion of one interview where two interviewees participated at the same time. Six of the interviews were conducted in Finnish and three in English. All of the nine interviews were conducted to different companies and mostly from different industries in order to get a wide perspective on the subject. Table 5 shows the interviewees' general role within their organization and the field of business the organization focuses on. In addition, all of the interviewees were informed that the sources of information will be masked so that, nor the name of the person interviewed nor the name of the organization they represent will be revealed. The people interviewed are masked as Interviewee A, Interviewee B, …, Interviewee J, as shown in Table 5 to protect the identity of the interviewees. All of the interviews were done online via Microsoft Teams, recorded with the interviewees' permission, and the records were transcribed into open text afterwards.

Table 5. The interviewed people, their experience, and their industries.

Interviewed person	Role (generalised)	Field of business
Interviewee A	Head of Intelligent Automation	IT consulting
Interviewee B	Head of Intelligent Automation	Intelligent Process Automation services provider
Interviewee C	Chief Business Officer	RPA provider
Interviewee D	Operational Technology Manager	Electronics manufacturer
Interviewee E	Chief Digital Information Officer	BI services provider
Interviewee F	Process Analyst	Public service provider
Interviewee G	Process Specialist	Public service provider
Interviewee H	Head of Department	Speciality chemicals supplier
Interviewee I	Automation & AI Manager	Telecommunications manufacturer
Interviewee J	Global Automation Program Leader	Pharmaceutical manufacturer

The interview transcriptions comprised most of the data used in the analysis. Some support was provided by the theoretical framework, for example, in coding. First, in the analysis, results from the interviews were coded by diving the data into categories based on the questions they answered. For each category, more detailed comments from the interviews were added to get a deeper understanding of the topic. Based on the answers in each category, answers to the research questions began to form. The interview results were also compared to the findings from the literature to see if they supported the previous literature or not.

4 RESULTS

In this chapter, the results from the interviews are introduced and analysed. The findings of this chapter will be used together with findings from the literature to answer to all of the research questions. The chapter is divided into sections based on the category of the answers received from the interviewees. Some of the answers came up while the interviewees were asked about something else apart from the specific category in this chapter, e.g. some benefits were discovered when the interviewees were answering to a question about challenges with RPA. Such findings will be analysed on the benefits category in this chapter.

4.1 Benefits of RPA

This section focuses on analysing the different benefits to create an understanding of what types of benefits the interviewees have found from RPA and how they can affect the performance of business. The different categories of mentioned benefits can be seen from Figure 14 which shows how many interviewees mentioned a benefit of RPA from each category. In this context, the categories are based on the content of the comments made by the interviewees. Even though the interviewees did not specifically mention the category shown in Figure 14, but their comments are implicating to such category, they are listed under that specific category. The idea behind the categories used in this section is better understood with an example:

> (1) "*Yks, että se [RPA] standardoi sen prosessin, minkä se automatisoi ja tietenkin poistaa ne inhimilliset virheet siitä, jos se [RPA] on oikein toteutettu. (One thing is that RPA standardizes the process it automates and of course removes the human errors from the process if RPA is correctly implemented.)* (Interviewee E).

For instance, in example (1) we can see that process quality is not directly mentioned in the comment, instead, the comment includes thoughts about RPA improving standardisation and removing errors which results in improved process quality. Such a comment is still categorized as "Improved process quality" in Figure 14 as that is essentially what the comment is about. The same logic persists through all the sections in this chapter.

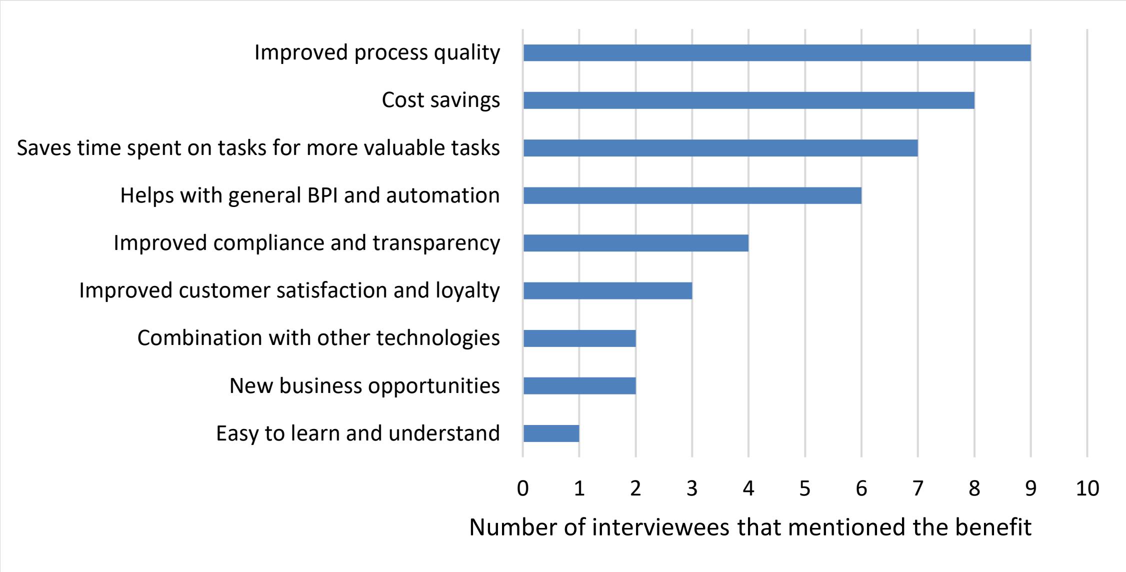

Figure 14. Benefits of RPA discovered from interviews.

4.1.1 Process quality

Improved process quality was the most often mentioned benefit in the interviews, but interestingly, none of the interviewees directly said that it is the most important one. One reason for this may be, as Interviewee C mentioned:

> "*[…] se [laatu] on ehkä jossain määrin vaikeesti mitattavissa oleva asia […].*" *([…] the quality is somewhat challenging thing to measure […].).*

Another point to make about improved process quality is that it is the result of multiple changes that RPA makes to processes. Such a change can be the removal of human errors or process standardization as shown in example (1), where RPA improves process quality since it removes the human errors from processes. Only if the robot is not developed correctly in the first hand, will it make errors. Two examples of common human errors that can be fixed with RPA are presented in example (2):

> (2a) "*[…] hankintapuolen asioissa, että jos me on prosessissa määritetty tietyt tarkastukset, mitkä pitää tehä ja ehot, mitkä pitää toteutua, että me lähetään jotaki*

> *hankkimaan. Niin sillon on hyvin paljon mahollista, että kun normi ostaja tekee ja käy päivässä läpi satoja rivejä, niin tuleeko ne kaikki tarkastukset sitte tehtyä vai skipataanko siellä sitten.*"*([…] in procurement, if we have defined a process with some specific checks that must be done and some conditions that need to be fulfilled before we begin to acquire something. Then, it is very likely that when a normal buyer creates and goes through hundreds of rows a day, are all of the checks made or are some skipped.)* (Interviewee D);
>
> (2b) "*Jos sä käyt verikokeessa niin robotti voi vaikka tarkastaa, että nyt se lääkäri on muistanu käyä tarkastamassa ne verikokeen tulokset.*" *(If you go to have a blood test, the robot can, say, check that the doctor has remembered to check the results of the blood test.)* (Interviewee B).

In both of these examples, RPA is used to make sure that human employees do not forget to do some simple, yet important, activities that likely occur multiple times a day. Forgetting to do these activities can result to reduced compliance and bad decisions (2a) or to customer dissatisfaction (2b).

Another change contributing to improved process quality can be found in example (3):

> (3) *"[…] robottihan on nyt oikeestaan semmonen superhyvä, koska se nyt sitten tekee aina samal taval saman asian, eikä sitä vaihtelua synny. Käsittelee just niin ku sille [robotille] on määritelty, niin saadaan se laatu, tehtävien laatu, miten sitä suoritetaan, niin se on niin ku aina sama.*" *([…] robot is actually super good because it always does the same thing in the same way and variation is not formed. RPA handels activities just like it is configured, so we get the quality, the quality of actions performed, to always be the same.)* (Interviewee F).

Since the robot always follows the same steps, it naturally reduces (or removes) variation from the process which on the other hand improves process standardization and quality. Process conformance and transparency are also increased because the robot's steps are documented on a detailed level, making it easy to follow those steps and find possible non-conformances.

4.1.2 Helps with general process improvement and automation

Four interviewees mentioned that RPA works as a catalyst for process improvement and automation in general, which can also be associated with improved process quality. As Interviewee A has put it in example (4):

> (4) "*Sitte ku me päästään siihe et mite siin koko prosessissa voidaan tehdä asioita nopeemmin, paremmin, ehkä jopa vähän eri tavalla, useemmin ja sillä tavalla saadaan vaikka asiakastyytyväisyyttä tai hankinnan tehokkuutta tai oikea-aikaisuutta nostettua ja sitä kautta tuotuu miljoonien [eurojen] liiketoimintahyötyjä, asiakasuskollisuutta ni sillon tavallaa ollaan siel oikeessa RPA:n suolassa. Se ei oo välttämättä se pelkkä RPA, mut sit mennään vähä siihe älykäs automaatio suuntaan samalla, et prosessien muokkaaminen ja useemman teknologian tuominen. Mut se on mun mielestä se RPA:nki tärkein oikee hyöty.*" *(When we reach the point of how to do things faster, better, maybe in a bit different way, more often in the whole process. When in this way, we are able to, for example, increase our customer satisfaction or procurement efficiency or on-timeliness, and provide business benefits worth of millions of euros along with customer loyalty, then we are in the real core of RPA. It is not necessarily only RPA, we go towards Intelligent Automation, modifying processes and onboarding multiple technologies. But, in my opinion, it is the most important benefit of RPA, too.)* (Interviewee A).

Example (4) highlights that RPA is not only affecting the process quality itself, but it affects the entire way of doing business in the organization. Indeed, Interviewee A continued by saying that

> "*[…] RPA on tietysti katalysti prosessin standardoimiselle ja automatisoinnille ihan yleisestikki.*" *([…] RPA is of course a catalyst for process standardisation and automation in general.).*

First, from process improvement perspective, RPA helps by standardizing processes, which is necessary to implement RPA, and by providing more improvement opportunities since RPA provides new information for the organization about their processes:

> "*Käytännössä me tuotetaan uutta informaatiota ohjelmistorobotiikan avulla meille liiketoimintaan.*" *(In practice, we produce new information for our business with RPA.)* (Interviewee G).

Second, in terms of automation, Interviewee A mentioned that when RPA is first introduced to the IT teams and business gets excited of the fast development of RPA, the IT teams actually begin to develop traditional IT automation faster as they see it will be better suited for specific processes as discussed previously in sub-section 2.2.6. This kind of behaviour will speed up the automation transformation in companies. Two main characteristics of RPA that help to speed up automation are shown in example (5).

> (5a) "*It [RPA] helps us to really deliver outcomes fast compared to other parts of IT or traditional IT. […] So, I think the benefit of RPA and automations is that we can deliver a lot of these quick turn-arounds and benefits that the business seeks, while also keeping them secure and stable and scalable.*" (Interviewee I);

> (5b) "*In general, it's [RPA] a software that is very quick in terms of implementation. There are not many other automation offerings, unless VBA, where you can help people quickly with process automation. RPA can definitely help to realize quick wins. […] Also, RPAs are scalable. You can do a pilot quickly in country XYZ and considering the same system and the same interface, you can then easily scale that globally if the process is more or less standardized and harmonized.*" (Interviewee J).

These characteristics are RPA's fast development speed and its scalability. The fast implementation speed makes it possible to realize quick wins with RPA as mentioned by Interviewee J. The quick wins were also highlighted to help with RPA's implementation in the literature. Another important consideration is the scalability of RPA which makes it possible to use the same bots in different locations when the processes are somewhat standardized between each other.

4.1.3 Cost savings

Cost savings came up in almost all of the interviews. Cost savings were thought to be the most important benefit by many because it is behind many of the other benefits. This was also brought up in example (7). In this example, the additional benefits can be associated to new business opportunities that RPA enables. RPA makes them possible by lowering the cost of the activities and by making the activities faster. This way something that would not have been profitable previously, can be transformed into profitable business or increase existing customer experience by lowering the cost of services or by serving them with something extra for the same price.

> (7) "*Joo, niitä [hyötyjä] on tietysti paljon ja niistä on paljon kirjotettu ja niitä on ehkä vähän hakemalla haettu että oikeesti ne tietysti vähän vaihtelee caseittain, mut kyl se tärkein on selkeesti se kustannussäästö. […] Sen lisäks, mihin mennään on sitte liikevaihtoo lisäävät automaatiot eli automaatiot, jotka pystyy palvelee asiakasta paremmin tai tekemään toimenpiteitä, joilla saadaan uusia liiketoiminta-alueita. Nekin tyypillisesti tulee sitte sen kustannustehokkuuden kautta.*" *(Yes, there are of course many benefits, and a lot has been written about them and likely they are a little made up, so in reality it depends on the case, but the most important one is the cost savings. […] In addition, where we are going are those automations that can increase sales. So, such automations that can serve the customer better or perform actions to acquire new business areas. They are typically acquired through the cost efficiency.)* (Interviewee B).

Intrestingly, Interviewee B highlighted the importance of cost savings compared to other benefits and provided some doubt about other possible benefits. This may be due to cost savings or reductions being the main KPI that is typically used to build the business case behind RPA's implementation as stated by Interviewee D:

> "*Kyllähän sitä yleensä kylmästi lähetään laskee, paljoko sitä työaikasäästöä voijjaan saaja.*" *(Usually we coldly start to calculate, how much work time savings we can get.)*.

Interviewee E also emphasized the fact that ROI is typically the deciding factor when deciding between multiple use cases for RPA:

"*Päätöksentekohan yleensä tällä ROI:lla tehään, että mistä se saadaan se suurin hyöty suhteessa siihen panostukseen.*" *(Decision making is typically done with ROI, so where we get the largest benefit related to the investment.")*.

4.1.4 Time saved for more valuable tasks

Cost savings are the result of time savings which are acquired by RPA doing activities faster than human employees. The saved time of human employees can, therefore, be used for other tasks that require human judgement and provide more value to the customer. As Interviewee C said:

> (9) "*Työajansäästöt on tietysti se et vapautuu se työaika ehkä vähän fiksumpiin tehtäviin, et se on tietysti se et päästään niist turhista rutiineist, tylsistä hommista eroon ja pystytään keskittymään sitte vähä fiksumpiin juttuihi.*" *(Work time savings are of course that the work time is freed for somewhat smarter tasks, so we get rid of the unnecessary routines, dull tasks, and that we are able to focus on smarter things.)*.

In example (9), dull tasks and unnecessary routines refer to activities that are simple daily work that do not require human consideration and, thus, can be automated with RPA. The human time saved from these tasks can then be used in smarter things that can be considered to provide more value to the organization and to the customers. This type of change in the workplace will likely also increase the employee satisfaction in the organization as the dull tasks are no longer a part of emplyees' daily life.

Although RPA is typically advertised to be used for simple tasks, Interviewees F and G mainly use RPA on more complex tasks such as checking information or prefabrication of certain data, as they have already automated all the simple data queries (where RPA is typically first introduced to) with batch processing technology. This finding shows that RPA can be applied to more complex processes while also increasing employee and customer satisfaction. However, in this case, the time invested in robot configuration may be increased and the benefits of RPA may be realized more slowly when compared to very simple tasks.

Interestingly, in examples (10a) and (10b), interviewees brought up that the processes automated with RPA were so much more efficient that it was no longer an option to hire human labour to do those tasks in case a bot stopped working.

> (10a) "*Eli prosesseja, joita ei ois pystytty kohtuullisessa ajassa manuaalisen työvoiman avulla käsittelee ilman sitä robotin saatavuutta. […] et pystytään niitä prosesseja pyörittää ja sitä asiakasta [palvelemaan]. Siihen ei pystytä ellei sitä automaatiota ole.*" *(So, processes that would not have been able to be managed in a reasonable time without robot's availability. […] so that we can run those processes and [serve] the customer. That is not possible without automation.)* (Interviewee B)

> (10b) *"[…] if the robot stops one day, there should be someone who can backup this process. […] in our case this process, which took half of the day, was performed by a person. […] Then, if a robot stops, there should be technical support at once.*" (Interviewee H)

As mentioned in examples (10a) and (10b), in such cases it seems to be very important to have properly designed back-up systems in place to ensure that the business can continue to serve the customers. Even though speeding up the process is obviously sought-after, it can also create new risks for the organization to consider. Various risks of RPA will be discussed in section 4.3.

4.2 Challenges of RPA

In this section, the challenges that came up in the interviews are introduced and their effects on RPA's implementation and usage are analysed. In addition, this section aims to understand the reasons behind those challenges and the possible linkages between them. The challenges were categorized in the same fashion as in section 4.1, as is presented in Figure 15. It is worth noting that quite many of the challenges are related to each other, and therefore, the amount of mentions for each challenge in Figure 15 does not necessarily give any reference to their criticality. Rather, a high number of mentions suggests that the specific challenge is commonly seen within RPA implementations.

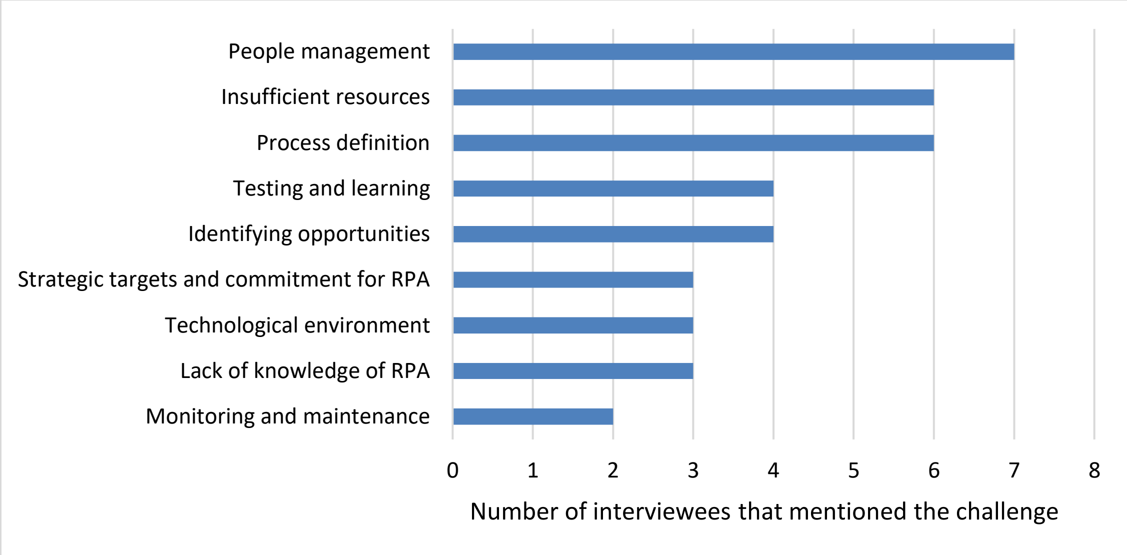

Figure 15. The challenges of RPA mentioned in the interviews.

4.2.1 People management

Most of the challenges mentioned in the interviews were related to people management. Managing people consists of many types of challenges. The first challenge is getting people involved with the RPA's implementation project as can be seen from example (11).

> (11) "*The most challenging part throughout the whole RPA program and any project is having the SME (subject matter expert) involved and ensuring he is onboard. […] without them, […] you will not have good RPAs, and they will also not be accepted by the business.*" (Interviewee J)

The subject matter expert in example (11) is critical to RPA's success as they are the people who know the process and will be using RPA daily. The involvement of the to-be users of the RPA robot is necessary as RPA developers do not necessarily know the process that well, as discussed below in sub-section 4.2.2. The lack of time involved to the development of RPA by employees does not necessarily mean that people do not want to have RPA on their team. This is highlighted by comments such as:

> (12a) "*Ei oo meillä törmätty muutosvastarintaan, tämmösii "robotti tullee ja vie mun työt". Enemmänkin porukka on ymmärtänyt, että se [RPA] tullee niiku auttamaan ja poistamaan niitä tylsimpiä rutiineja." (We have not encountered any*

change resistance like "the robot comes to take my job". Rather, people have understood that RPA comes to help them and remove the most boring routines.) (Interviewee D);

(12b) "*[...] digityökaveri ei oo vielä niin tuttu kaikille. Ei se niinku haittaa sitä käyttöönottoa [...]. Ehkä enemmän on sit vaan se aika. Kun tehdään uutta ja ihmiset tartteis siihen enemmän aikaa omaksua asioita [...].*" *([...] the digital co-worker is not so familiar to everybody. It does not hamper the implementation [...]. Maybe it is more associated with the time. When we are creating something new and people would need more time to take things in [...].)* (Interviewee F);

(12c) "*Sanotaan, että pääsääntösesti suurimmalta osin tosi myönteinen vastaanotto tälle tekemiselle [RPA:lle] on kyllä ollu. Yllättävän vähän kritiikkiä tästä on tullu.*" *(For the most part, there has been a very positive reception for RPA. There has been surprisingly little critic out of it.)* (Interviewee G).

The comments in example (12) indicate that employees are not hostile toward RPA robots, instead, the reason behind the lack of involvement from employees is likely to come from the strategic targets and commitment set by management as they are ultimately deciding how much time and other resources are invested into implementing RPA. This point was also highlighted by Interviewee B, who explains the challenge as:

"*Eli se ambitiotaso, mikä siellä yrityksessä on ja se tuki ja paine, mitä toiminnalle luodaan ja investoinnit siinä. Ymmärretään, että siinä pitää myöskin investoida siihen [RPA:han], jotta ne tulokset saadaan. Se on ollu keskeisin edellytys.*" *(The level of ambition in the company, and the support and pressure that is given to the activities, and the investments. It is understood that RPA also requires investments in order to receive the benefits. That has been the key pre-requisite.)*.

This comment by Interviewee B suggests that people management and the success of RPA is very depended on the strategy and goals of RPA communicated in the organization, and not so much about the fear or anxiety towards robots as often cited in the literature.

However, some interviewees had experienced some levels of change resistance initially as mentioned by Interviewee I:

> "*It varies per team, but if RPA is something that replaces their job, then it's something they resist. Usually, it is doing something they don't like anyway […]. A lot of times they do see the benefit as well […].*"

This is likely due to the lack of knowledge about RPA as RPA technology is quite new, and people are not familiar with its effects on their jobs as noted by Interviewee F in example (12b). The lack of knowledge about RPA has also an effect on setting the strategic goals for RPA and identifying the best use cases and proper scope for RPA. Comments in example (13) provide further clarification on this issue:

> (13a) "*Front-end automation has certain limitations and if you only do RPA, you will have a graveyard, at a certain point of time, of bots. Because, our tools will evolve and the question will be, will you also maintain the bots, will you change the bot and so on. […] You need the other technologies like AI, you also need your legacy systems to be updated. […] I would frame that as 'Setting realistic targets and being aware of the general capabilities of automation'.*" (Interviewee J);

> (13b) "*Se on ihan selkee, että tästä automaatiosta saadaan hyötyjä siinä vaiheessa, ku se on laajamittaista toimintaa ja se edellyttää sen riittävän ambitiotason.*" *(It is clear that benefits from automation are received when the operation is large-scale, and that requires the high enough level of ambition.)* (Interviewee B).

Example (13) emphasizes that the management level of the organization also has to understand the capabilities of RPA in order to be able to set strategic targets for RPA. Understanding the capabilities of RPA is necessary to not develop RPA robots for the wrong use cases that may then transform into "graveyard of decommissioned bots" (13a). The capabilities are also important to understand when considering the scope of RPA's implementation. As highlighted in example (13b), RPA needs to be applied widely enough to claim the benefits of RPA, which requires setting proper strategic goals, and investing enough time and resources for RPA's implementation, which is meant by "ambition level" in example (13b). The strategic targets set by management will affect the whole organization's engagement and attitude towards RPA.

Coming up with the strategic targets and roadmap of RPA's implementation alone is not enough, but they also need to be properly communicated to the organization. The importance of communication is emphasized by Interviewee J, and the results of failure to do so are presented in example (14):

> (14) "*If senior management is doing a certain strategy roadmap in a dark room somewhere and it's not really properly shared and cascaded down on a middle management layer and they ask you to execute, middle management does not really know what you are doing and how that is fitting into the strategy and how they can benefit from RPA. So, they need to understand, what are the benefits associated with that, and how is this helping me to achieve my strategic objectives.*".

In addition to setting strategic targets and expressing the commitment of top management to RPA, teaching people about the benefits of RPA is important, as that is how to get them involved. When the employees begin to understand how they can benefit from RPA, it is easier to get them onboard with the development project. In addition, people management challenges were experienced in allocating roles and responsibilities for RPA in the organization as noted by Interviewee C:

> "*Suurin haaste on ehdottomasti asiakkaitten ajankäyttö. [...] Et siel on selkeet vastuunottajat, jotka vie sitä hommaa eteenpäin. Semmoset yritykset missä se organisaatiorakenne on sillai et siel on RPA-ryhmä syntynyt ja se on innostunu siitä ja heil on aikaa käytettävissä niin ne onnistuu. Sit jo sitä aikaa ei oo käytettävissä niin sit homma hidastuu.*" *(The greatest challenge is definitely the time management of the customers. [...] So that there are people who are responsible of RPA and make it go forward. Those companies where the RPA organization has been formed and the people in the RPA organization are excited about it and have time available for it, are successful. Then again, if there is no time available, the implementation slows down.).*

However, this challenge is also associated with getting the sufficient time investment from organization to RPA's implementation since as previously mentioned, the time investment for RPA is typically decided by the top management of the organization.

4.2.2 Process definition

Another major challenge that came up in most of the interviews was associated to process knowledge, namely definition of the process. Process needs to be defined and documented on a very detailed level to be able to configure RPA. This fact was highlighted also by Interviewee H:

> "*[…] the most challenging was to write down this process flow so detailed, let's say. In order to automatize all this, everything should be written very detailed.*".

Example (15) introduces the thoughts of an experienced RPA user and developer when asked about the challenges of RPA's implementation:

> (15) "*Ensimmäinen on tietysti se, jossa prosessin määrittely on puutteellinen tai viallinen ja sitä ei oo huomattu. Se voi johtua monest syystä. Joskus se voi olla niin, että se dokumentointi tapahtuu vaan sen tiimin toimesta ja that's it, sit ruetaan devaamaan ja todetaan, että siinä [prosessin määrittelyssä] on aukkoja tai puutteita tai epäloogisuutta. Toinen voi olla se, et se prosessi on sen verran monimutkanen ja monisyinen ja siel on erilaisii poikkeuksia ja poikkeuksen poikkeuksia, et niitä kaikki ei vaan saada kapturoitua siinä dokumentointivaiheessa, vaikka siin ois miten kokenu automaatiodokumentoija tai konsultti sitä kattomassa. Et se on ehkä semmonen kliseisin murheenkryyni, että ensin pitäs määritellä ja sit toteuttaa.*" *(First one is of course that where process definition is inadequate or defective and it is not noticed. That can be caused by many reasons. Sometimes it can be that the documentation is done only by the development team, after which the development begins, and we realize that there are gaps or defects or illogicality in the process definition. Another reason can be that the process is so complex and tricky, and it has different exceptions and exceptions of exceptions that all of them are just not possible to be captured in the documentation phase, even though, the automation documentor or consult*

> *is very experienced. So, maybe the most cliché source of grief is that you need to first define and implement afterwards.)* (Interviewee A).

Based on example (15) the major challenge in RPA's implementation is using an imprecise process definition to configure the robot. The first cause mentioned in the example is due to RPA developers working separately from the process team that works daily with the process and have the best process expertise. A similar challenge associated with the lack of co-operation was also noticed in sub-section 4.2.1 during the discussion about the lack of involvement of employees and their time investment. In example (11), Interviewee J emphasized on the importance of getting SMEs onboard with the development of RPA, and the same applies to process definition as it is an essential part of the development of RPA. The lack of process knowledge causes the process definition phase to take more time as explained by Interviewee G:

> "*Määrittely meillä vie aika paljon aikaa. Se tietysti johtuu myös siitä, [...] että meillä määrittelijät voi olla semmosia, kun tulee uus prosessi käyttöön, että se on hänelle sitten uusi asia tälle, joka liiketoiminnanlogiikkaa sitten määrittelee robotille.*" *(For us, process definition takes a lot of time. It is of course due to [...] that when we have a new process to implement [RPA on], the process is also new for him who is defining the business logic for the robot.).*

The second point in example (15) was that processes can be very complex, containing multiple exceptions that realistically cannot be foreseen before RPA is introduced into production. The same challenge was experienced by Interviewee F as their organization applies RPA for more complex processes:

> "*Tavallaan se [haaste] kuuluu siihen bisneslogiikkaan just. Tosiaan ku me ei välttämättä tehdä niitä kaikkein helpoimpia (prosesseja), niin sitte se robotille se määrittelytyö voi vähän kestää.*" *(In a way the challenge is related to the business logic. As we do not necessarily apply RPA for the easiest (processes), the robot's definition can take some time.).*

As these comments suggest, process definition is a time-consuming phase of RPA's development. However, it needs to be done in a good manner since an inadequate process definition will create more problems later on. Examples of problems caused by poor process definition are shown on example (16).

> (16a) "*If the SME has not described the process well and during the user acceptance testing you realize, oh why didn't we cover that "I forgot, I didn't know"*." (Interviewee J)
>
> (16b) "*There were some challenges with the testing as well, but again, it was because they should have provided all these detailed instructions [definitions]*." (Interviewee H)

In example (16a), Interviewee J talked specifically about SMEs, but it does not mean that SME should be defining the process alone, instead, the entire RPA development team should be involved in the process definition. It is important to note, however, as mentioned in example (15), not all the exceptions can be captured during process definition phase. This means that these exceptions will be faced later on in the testing phase of development or when the robots are introduced to production. In Figure 15, these types of challenges are referred to as "Testing and learning". In addition to proper process definition, to ensure that as few exceptions as possible make their way to production, testing needs to be thorough as noted by Interviewee F:

> "*Totta kai sitten haasteellisuuksia voi olla myös testitapaukset, koska me kuitenkin testaamme ensin testiympäristössä ennen ku menemme tuotantoympäristöön.*" *(Obviously, the test cases can also be a challenge since we have tests in a testing environment before going to production.)*.

Another challenge partly caused by poor process definitions is faced when the organization tries to identify new use cases for RPA. In example (17a) process definitions are inconsistent due to organizations varying methods of defining the processes. When different processes are defined using different methods, it becomes hard to compare different ideas and processes with each other evenly when trying to find out which of them are the best candidates for automation.

(17a) “*[…] uusien ideoiden kerääminen ja niitten kohteiden tunnistaminen, niin siinä on myös haasteita. Koska meillä on melko iso talo kyseessä ja meillä on valtava määrä erilaisia prosesseja ja niitä on vuosien varrella kuvattu erilaisilla käytännöillä, eri kirjavilla järjestelmillä ja muuta.*” *([…] gathering new ideas and identifying the use cases has also provided challenges. That is because we are a quite large organization and we have an enormous number of different processes which have over been defined with different methods and systems over the years.)* (Interviewee G)

(17b) “*Kyllä se yllättävän haastava on se kohteiden tunnistaminen. Omalla kokemuksella voin sanoa, että oli se sitten RPA:ta tai perinteistä automaatiota, mutta ehkä se on enemmän sitten sitä, että ei meilläkään ihan kaikki ymmärretä, että mitä kaikkea nykyautomaatiolla on tehtävissä.*” (*It is surprisingly difficult to identify opportunities for RPA. In my personal experience I can say that whether it is RPA or traditional automation, it is more about that we do not fully understand what kind of activities can be performed with today’s automation.)* (Interviewee D)

(17c) “*Gathering ideas is easy and fast, but finding the best cases is the challenge.*” (Interviewee J).

In addition to challenges provided by poor process definition, the lack of knowledge about RPA’s capabilities provides a challenge when identifying new use cases for automation as expressed in example (17b). To tackle this challenge, the organization needs training on RPA, so they learn more about the capabilities and benefits of RPA as mentioned previously in sub-section 4.2.1. When the organization understands what the advantages of RPA are, they are better prepared to identify the best use cases from the gathered ideas which is one of the challenges as noted in example (17c). Without the knowledge about what RPA can do, and in which types of processes it can be used, it likely is very challenging to decide on the best candidates for RPA, especially when there are also other automation methods to be considered.

4.2.3 Technological environment

A phrase that came up in many of the interviews when talking about the technological challenges in RPA's implementation was something aligned to "*Technology is easy, but people are hard*" as can be seen from the following comments:

> "*Joo et ei se tekniikka oo se juttu [haaste], vaan enemmän se on just siitä, et miten se joko kokonainen RPA Center of Excellence tai virtuaaliorganisaatio kehitetään sinne sen puitteissa et ihmisillä ois ajankäyttö käytettävissä. Se on se suurin juttu.*" *(Technology is not the challenge, rather, it is how to create the whole RPA Center of Excellence or the virtual organization, within which is the challenge of people having enough time available. That is the biggest thing.)* (Interviewee C);

> "*Tekniikka on helpointa et mitenkä se tehdään se asia. Kaikki muut siitä ympäriltä on sitte isompi juttu.*" *(Technology is the easy part on how to do it. All the rest around it is more challenging.)* (Interviewee E).

However, there still are some challenges of technical nature. Some of the technical challenges are provided in example (18). The first challenge that came up from the technical side was building up the technological infrastructure for RPA which was a challenge for Interviewee D due to his background.

> (18a) "*Yleisiä ongelmia mitä on nähty, että teknologia, minkä päälle se [RPA] on rakennettu. Niin on lähetty rakentaa RPA:ta jonku läppäriympäristön päälle johtuen, vaikka jonkun teknologiatoimittajan lisenssimallista et saat kokeiluversion ilmaseksi tai halvalla ja sitä [RPA:ta] lähetään rakentamaan siltä läppäriltä tehtäväksi. […] Se skaalattavuus törmää seinään siinä aika pian, kun sitte haluttas saada hyötyjä.*" (*Common problems that we have seen is the technology on which RPA is built on. RPA has been started to build on top of laptop environment, for example, because of some technology provider's licensing model so that you will get a trial version for free or cheap and that has been used to build RPA from the laptop. […] The scalability hits a wall very fast when you would like the receive the benefits.)* (Interviewee B)

(18b) "*No varmaan omalta osalta se [haastavin asia] on ollu nimenommaan tuo tekninen puoli. Mun historia on valmistuksessa, että ei oo IT taustaa, nii se että osata luoda ympäristö, missä voi tosiaan ykstoista tehasta pyöriä ja luua robotteja, olla serveriympäristöt, remote desktopit ynnä muut.*" *(Well, on my personal experience the most challenging aspect has particularly been the technical side. My history is in production, so I do not have IT background. So, to know how to create an environment where eleven factories can run and create robots, to have server environments, remote desktop, and so on.)* (Interviewee D)

In vast amount of the case studies presented in the literature, RPA is claimed to be easy to use and that it does not require any technical skills. Example (18b) somewhat contradicts with that statement in the sense that Interviewee D had indeed faced problems due to the lack of technical skills. However, there may be a difference on what is meant by this phrase in the studies. Since using the RPA software can be manageable even without technical skillset, but the infrastructure behind it is not. Setting up the technical infrastructure for RPA is still necessary and important to be able to scale the operation and obtain the most benefits out of RPA as discussed briefly in sub-section 4.2.1. Furthermore, as Interviewee B notes in example (18a), setting up the infrastructure improperly can hamper with the scaling of RPA which can withhold some of the desired benefits of RPA.

The last challenge is related to maintenance and monitoring of the bots. This phase involves managing the possible changes to the systems or to the processes. As Interviewee D mentions in example (19a), it is hard to change the process after RPA is deployed. This is due to the fact that RPA has to be re-adjusted to the change, which will of course take time. Also, the change in process can cause new exceptions to emerge which need to be considered when updating the robot in that process. Moreover, when there are many robots applied to multiple processes that are performing activities in interfaces of multiple different system, all the changes to all these different systems need to be managed.

(19a) "*The biggest challenges are changes to the systems. We have to keep track of all the systems where RPA is deployed so that we can test it on the new version before the systems change.*" (Interviewee I)

> (19b) "*Usein se alkuvaiheessa ajatus ja osaaminen riittää siihen, että ajatellaan, että nyt ollaan saatu kehitettyä tää [RPA], että nyt tää toimii. Mut sit käytännössä kuitenki se automaatioki vaatii ylläpitotoimenpiteet ja seuranataa. Se on ehkä yks näistä tyypillisistä pullonkauloista, joka puuttuu.*" *(Often the initial competence is enough to get the RPA developed and into operation. However, in practice, the automation also requires maintenance and monitoring which is maybe one of the typical bottlenecks that are missing.)* (Interviewee B)

In order to be sure that all the robots are up and running, the robots need to be monitored and maintenance is required after the initial implementation. This is often forgotten by inexperienced users as noted by Interviewee B in example (19b). Some events of this type that may come as a surprise to inexperienced users were also listed by Interviewee A:

> "*Kokemattomalla RPA:n toteuttajalla haasteita voi olla sit tietysti niiku ylipäänsä vikasietosuus, automaattinen toipuminen poikkeamista [esimerkiksi sähkökatkos]. […] Niinku näihin liittyvä just se valvonta, lokitus, hälytykset, ylläpito, nii kyl ne on semmosia niinku kokemattomalle taas semmosia murheenkryynejä.*" *(For inexperienced RPA users, the challenges can generally be fault tolerance, automatic recovery from exceptions [e.g. power outbreak]. […] The supervision, logging, alarms, maintenance associated with these are challenges for inexperienced users.)*.

As Interviewee B said in example (19b), these are initial challenges. Therefore, it is likely that they will not be that much of an issue later on when the users gain experience and knowledge of RPA as is the case with building up the technical infrastructure discussed previously in this sub-section. Overall, the challenges of RPA seem to not be related so much on technology itself, but the aspects around it.

4.3 Risks of RPA

This section focuses on the risks associated with RPA's implementation that need to be identified and managed. If the risks are not dealt with, they can cause some of the challenges listed above in section 4.2 or hinder some of the benefits listed in section 4.1. The risks were categorized to understand, how they affect each other and to find out if there are any linkages between them. As in previous sections, the mentioned risks are listed in Figure 16. An important thing to notice, however, is that the number of mentions does not reflect the severity of a given risk. The number of mentions merely describe, in how many of the interviews the subject was spoken of.

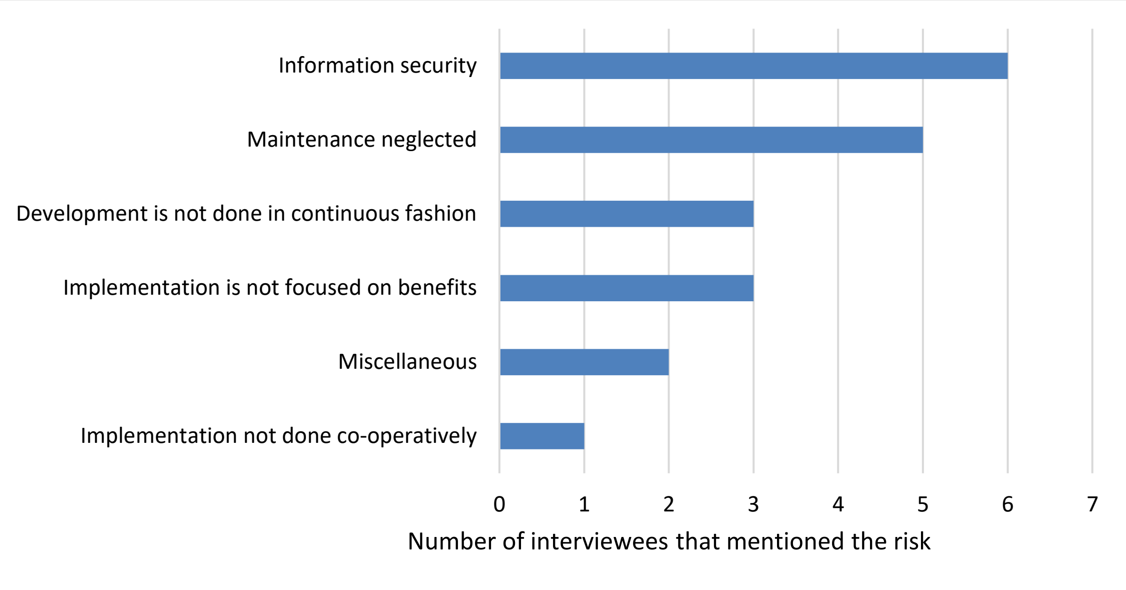

Figure 16. Categorized risks based on the interviews.

The three major categories that rise up from the interview data are risks related to implementation, maintenance, and information security. Later on, in this section these major categories are also broken down to more specific risk areas within the categories.

4.3.1 Risks in implementation

The risks with implementation consist of development practices. In Figure 16 these areas are the lack of development's continuous fashion, co-operation, and focus on benefits. Firstly, example (20) considers how the lack of focus in the benefits can create a risk for RPA.

> (20a) "*[…] olennainen asia on liiketoiminta hyötyihin keskittyminen. Implementoitujen automaatiopätkien lukumäärä ei pitäis olla se, mikä mitataan irrallisena asiana, vaan pitäis miettiä koko automaation elinkaaren kokonaiskustannusta ja niitä hyötyjä, mitkä on realisoitu tai realisoitumassa yksittäisten automaatioiden kautta.*" *([…] an essential thing is the focus on the business benefits. The number of implemented automations should not be the main*

> *consideration, instead, the costs of the whole lifecycle and the materialized benefits or those to be materialized through the automations should be considered.)* (Interviewee A)
>
> (20b) "*[…] meilläki on 11 tehasta et jos kaikki lähtee tekemään kaikkia mikä on kivaa automatisoida, niin meillä kohta se robotti tekkee jotakin ihan konsernin näkökulmasta tyhjän päivästä työtä 24/7. Että sinne meni meidän investointi ja robotti on kuormitettu täyteen, mutta varsinaisesti mittään paybackiä ei saatu.*" *([…] we have 11 factories, so if everyone starts to automate whatever is fun to automate, we will have the robot doing trivial activities 24/7 from the group's perspective. So, there goes our investment and the robot is fully loaded, but no payback is received.)* (Interviewee D)

As previously discovered in sub-section 4.2.1, RPA requires certain investments before any benefits can be achieved. Therefore, it is essential that those investments are directed towards application areas that have the potential to yield benefits widely in the organization. As highlighted by Interviewee A in example (20a), the implementation decisions should be based on the overall costs and benefits to be gained from RPA. The same observation was also made by Interviewee D in example (20b), who emphasized that the implementation decisions should be based on the expected payback since there are always costs introduced when automating processes. Therefore, there is a risk of choosing wrong use cases on which to implement RPA.

A factor that may decrease the potential benefits of RPA is the lack of co-operation in the company when RPA is implemented. Interviewee A brought up two points that can hinder the benefits:

> " *Jos IT ihan yksikseen valitsee liiketoiminnalle RPA-työkalun, niin saattaa käydä niin, että kysytään, mikä on lisenssin hinta kullakin näistä ja me otetaan se, mikä on halvin. Unohtuu tavallaa se käyttötarve […]. Sit taas, jos bisnes iha yksinään tekee sitä (RPA:ta), niin unohtuu ehkä tietoturva, jatkuvuus, ehkä sitä (RPA:ta) asennellaan vähä minne sattuun.*" *(If IT alone chooses the RPA tool for the business, it is possible that the cheapest license is chosen. The needs of the business are forgotten […]. Then again, if business alone implements RPA, it is*

> *possible that information security and continuity are forgotten, or that RPA is installed here and there.)* (Interviewee A);
>
> "*Jos sen [RPA:n] omistaa sitte joku yksittäinen tiimi tai organisaatio isossa groupissa. Sillonki, jos se [RPA] on sekä teknisesti että kannattavuudeltaan tehty täydellisesti nii on se riski, et se [RPA] jää sinne [tiimiin], koska se omistajuus on jossain tiimissä X ja niit ei välttämättä kiinnosta ollenkaa se, että miten se (RPA) skaalautuu muualle.*" *(When RPA is owned by a single team or organization in a large group, even if RPA is made perfectly in terms of technicality and profitably, there is a risk that the RPA stays in the team. This is due to that the ownership is in some single team which does not necessarily care about how RPA scales to the rest of the organization.)* (Interviewee A).

The first risk to consider is that if RPA is developed in silos, the needs of the whole organization are not properly understood or fulfilled. Another risk to consider due to lack of co-operation is that the benefits gained from RPA are not scalable or shared to the rest of the organization which again reduces the payback gained from the investments into RPA. When deciding about implementing RPA, the third consideration is whether RPA is the right tool for the task as there are plenty of other automation tools to consider. In sub-section 2.2.6 there was discussion about when RPA is the best option for automation. Another point of view to the matter was presented by Interviewee J while talking about the risks of RPA:

> "*If your automation strategy is only based on RPA, at a certain point of time you probably will have a graveyard of RPAs. Graveyard in a way that due to mergers and acquisitions and changing organizational structures, the IT landscape is also evolving, and certain RPAs were not enhanced […], so they are basically all delisted or decommissioned […].*" (Interviewee J).

Interviewee J emphasized the fact that RPA needs to be updated as the systems where it is deployed onto is updated or changed. If RPA is the only automation method, there is a chance that is not only likely to be less effective when compared to combining different automation tools (as discussed in sub-section 2.2.6), but it will also increase the total costs of using RPA. The costs are increased because as Interviewee J mentions, the robots need to be updated and if they are chosen to not be updated, they need to be delisted. Delisting would mean that the process would then return to manual labour which is not the most efficient option, or a new RPA robot would have to be developed. Therefore, RPA should be implemented in co-operation with the business and IT and the usability of the bots should be scalable across the organization, for example, by setting the ownership of the bots high enough in the organization and by making sure that the right process and automation tool is chosen.

Ultimately the purpose behind gaining benefits from RPA is to provide more value for customers. Creating more value for customers with RPA means that instead of humans, there are robots running the processes that create something of value to customers. Using robots for value creation was also mentioned to introduce some risks relating to the continuity of the business as we can see from example (21) below.

> (21a) "*[…] now we are off-loading a lot of work at our company to RPA, which means that if for some reason the bot goes down, the RPA software, then we can't perform a lot of the activities that we need to as company. Because we do not have the people to do it anymore in that sense.*" (Interviewee I)
>
> (21b) "*Tietysti se ylipäätänsä keskeisin riski on siinä, että miten saadaan tehtyä oikeella tavalla sitä toimintaa [automaatiota], että se tuottaa arvoa. […] Käytännössä liiketoiminnan jatkuvuus näkökulma tulee siinä merkittäväksi, et pystytään niitä prosesseja pyörittää ja sitä asiakasta [palvelemaan]. Siihen ei pystytä, ellei sitä automaatiota [robottia] ole.*" *(In the first place, the primary risk is how to do automation in a right way so that it creates value. […] In practice, the business continuity point of view becomes significant to be able to run the processes and serve the customer. It is not possible without the robot.)* (Interviewee B)

Both of the comments in example (21) emphasize that when RPA is implemented to processes, it is no longer possible to perform those processes at the same capacity with human workforce, and as Interviewee I mentioned, it is simply not possible to switch back to human labour. Obviously, if the process is not running due to e.g. bot breakage, no value is created to customers which could result in loss of sales and customers. Therefore, the continuity must be assured.

4.3.2 Neglection of maintenance

To preserve the continuity of creating value with RPA, the robots need maintenance, for example, when the systems they work on are updated, also the robots need to be updated (as discussed on sub-section 4.2.3). The neglection of maintenance was also brought up as one of the main risks with RPA by an experienced RPA developer. He highlighted two of the most important risks associated with RPA:

> "*Se, ettei ymmärretä ylläpidon tärkeyttä, keskitettyjen hallinta- ja valvontakomponenttien käyttöä. [...] Se, ettei ymmärretä dokumentaation tärkeyttä. Liittyy jälleen siihen ylläpidettävyyteen ja siihen, et joku muukin, ku se RPA:n koodannut henkilö osaa sitä [robottia] ylläpitää ja tietää, mitä sen pitäisi tehdä [...].*" *(That the importance of maintenance and the use centralized management and monitoring components is not understood. [...] That the importance of documentation is not understood. Documentation is related to maintainability and that someone else apart from the developer would know how to maintain the robot and knows what it should do [...].)* (Interviewee A).

The above comment suggest that activities related to maintenance are important and generate risks if maintenance is not considered when implementing RPA. Interviewee A highlights the importance of monitoring and management of the robots where documentation plays a vital role as it describes how the robot should work and what is the desired output from it. Monitoring on the other hand helps to identify possible failures based on the output of RPA. When multiple robots are implemented into multiple processes without management, the risk of bot failures rises. Similar thoughts were introduced by Interviewee B when asked about RPA's risks. He described that the lack of management may lead to uncontrollable chaos among the organization:

> "*Jos sulla ei oo selkeitä toimintamalleja mis on niinku elinkaari asiat mietittynä, tietoturva asiat mietittynä ja jatkuvuus mielessä, niin sit tulee helposti semmone hallitsematon kaaos.*" *(If you do not have clear operating models that consider*

> *lifecycle management; information security; and continuity, an uncontrollable chaos is easily introduced.)* (Interviewee B).

Management and monitoring related risks were also recognized by other interviewees. These risks are mainly focused on backing up RPA in case of failures, continuity considerations, and the monitoring aspect in terms of maintaining RPA's operation. These comments are presented in example (22):

> (22a) "*[…] jos ne robotit ei oo käytettävissä niin sitä asiaa ei saada tehtyä. Semmosta mahollisuutta ei ookkaa että sit otetaan sinne riviin henkilöitä jotka käsittelee, vaan sillon pitää olla varajärjestelyt, et miten se robotti saadaan takasin radalle.*" *(If the robots are unavailable, you cannot do the task. There is no such possibility as to take people to do the tasks, instead, you need to have backup arrangements on how to get the robot back on track.)* (Interviewee B)

> (22b) "*Se [RPA] pittää rakentaa siihen prosessiin hyvin tarkasti, että siinä on se oma laadun tarkkailu ja määrittää, että siinä on tietynlaiset prosessiin määritetyt tarkastukset ja jonkinlaine yhteenveto, että kun robotti on työnsä tehnyt niin se raportoi sitä jollekin. […] Ehkä nää suurimmat riskit on siinä [RPA:ssa], että jätetään valvomatta että mikä on se tulos.*" *(RPA needs to be built very carefully so that it has its own quality monitoring and define inspections into the process with some kind of a summary that is reported to someone after the robot has finished working. […] Maybe the biggest risks in RPA are that the output is not monitored.)* (Interviewee D)

> (22c) "*One risk is that we are automating a process that often times someone would do today, so you still have to be accountable for the output. If something goes wrong, you can't just tell someone to do it again or to do it right, but you actually have to fix the bot or the tech.*" (Interviewee I)

When using RPA, there is obviously a risk of bots failing or breaking down. The risk associated with bot breakage is that if there are no backup system available, the process is not able to run and as explained in example (22a), it may not be at all possible to replace the robot with human employees. Instead, as pointed out in example (22c), the robot needs to be fixed. Example (22b) emphasizes on the importance of monitoring RPA's work to ensure that the robot works as expected and that the output quality is satisfactory. If these actions are not taken, there is a risk that RPA produces outputs that do not satisfy the customer or creates problems later on in the process.

4.3.3 Information security

As already briefly brought up by Interviewee C in the previous sub-section, information security is a risk with RPA that must be considered and managed. Information security was always recognized as a risk within the interviewees, but it rarely was highlighted as the most important one. Rather, Interviewee E pointed out that RPA can be even more secure compared to humans due to the limited accesses and the nature of the passwords used with robot users:

> "*En mä näkis sitä [tietoturvaa] ongelmana. Samalla tavallaha se tekee ku käyttäjäkin ja ehkä vielä tietoturvallisemmin. [...] Teknisillä tunnuksilla yleensä salasanat on aika pitkiä ja hankalia ja ne oikeudet saattaa olla rajatumpia.*" *(I do not see information security as a problem. It works like a human user and maybe even more securely. [...] Technical credentials are usually quite long and difficult, and their rights may be more limited.)* (Interviewee E).

Similar thoughts were observed also in other interviews as example (23) below shows. However, it was emphasized that the information security risks need to be well managed.

> (23a) "*Tietoturva on semmone 'business as usual' joka jokasen asiakkaan kanssa läpi että miten se hallitaan. Tietysti se liittyy siihen et meillä on monia yksityiskohtia, mitkä pitää vaan hallita oikein.*" *(Information security is kind of 'business as usual' that needs to be managed with every customer. Of course, it has many details related to it that need to be well managed.)* (Interviewee B).

> (23b) "*Mehän tehdään tietoturva-analyysi kaikista robotisointikohteista, tai tämmönen riskianalyysi. Joten, en tiedä nähdäänkö se riskinä, vaan se on hallittavissa oleva asia.*" *(We do an information security analysis or a risk analysis on all of the robotization opportunities. So, I do not know if it is seen as a risk. Rather, it is a subject to manage.)* (Interviewee F)

> (23c) ”We *definitely see that [information security] as a risk and before we deploy a bot, we do a privacy and criticality assessment, like a standard IT privacy and criticality assessment. […] we deploy a lot of tech on-premise. So, instead of relying on the vendors to leverage their cloud, we try to make sure that as much of the tool that we deploy is within our environment and data is not sent to any outside vendor.*” (Interviewee I)

Examples (23a) and (23b) did not feel like information security is really a risk. Rather, it is seen a subject that needs to be well managed. Interviewee I in example (23c) recognized it a bit more strongly as a risk, but also highlighted that it has to be managed. As the example (23) shows, risk analysis and assessment practices are used to mitigate and manage information security risks within RPA. In addition, Interviewee I also favours on-premise installations to keep their data more securely within their own organization.

4.4 Process mining within RPA domain

This section focuses on discovering how process mining can be used together with RPA and to understand what kind of challenges or limitations there can be when using process mining together with RPA. As in previous sections of this chapter, the comments that came up in the interviews were categorized first into main category and later divided into sub-categories. One thing to note is that one of the interviewees had so little experience with process mining that it was not possible to sufficiently answer questions related to it. Therefore, this section covers one less interviewee than the previous sections.

The section first considers the benefits of process mining based on the thoughts of the interviewees. Secondly, this section introduces limitations and challenges of PM to consider when using it with RPA. For example, understanding potential limitations is important when analysing the results of PM as PM may not be able to capture all of the smaller activities in a process. Challenges of PM when used together with RPA are also important for future development of process mining software and overall usage.

4.4.1 Benefits of process mining

Considering process mining's benefits for RPA, mostly three main benefits were brought up in the interviews. These three benefits are fact-based process understanding, performance monitoring of RPA and processes, and identification of automate candidates. Figure 17 considers the benefits of process mining for RPA in the same fashion as in previous sections. The last two benefits in Figure 17, discovery of process inefficiencies and variations, were specifically mentioned quite many times, but they can also be considered to be included in the most often mentioned benefit which was the overall fact-based process understanding.

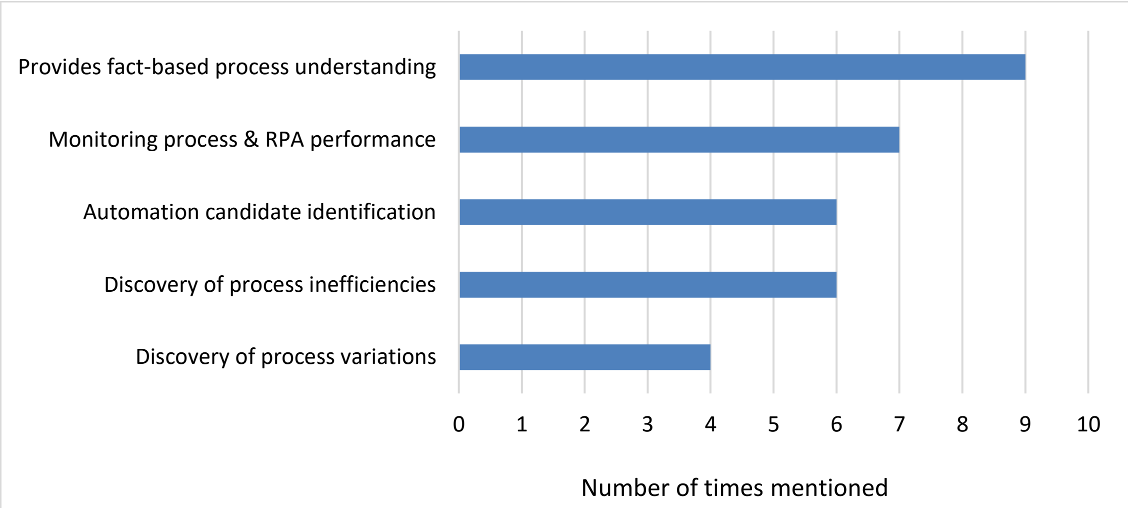

Figure 17. Benefits of process mining for RPA.

Fact-based process understanding is the most essential benefit as the data-based analyses are the foundation for other benefits of process mining shown in Figure 17. This is not only true for RPA, but also for other decisions that need to be made in business. As Interviewee J emphasized:

> "*If you implement process mining, you will get the true transparency on where you are. […] you will have the true facts and details you need to make right decisions and to ask right questions. That should be what any executive is driving for, looking at data-driven organizations.*" (Interviewee J).

Process understanding is a wide concept. For example, it includes discovering the process steps, finding process variations and inefficiencies, figuring out who are the process participants, and what are the bottlenecks in the process. Example (24) introduces thoughts of interviewees on the matter to better understand how PM can be helpful for better process understanding.

> (24a) "*Monet process mining -työkalut paljastaa tavallaan sen manuaalisten transaktioiden luonteen, tyyliin vaikkapa, että tietyssä prosessissa, niin tästä työvaiheesta manuaalisia transaktioita on puolet ja kaikesta manuaalisesta transaktiosta valtaosa johtuu tuosta yhdestä toimittajasta tai henkilöstä tai jostain muusta muuttujasta.*" *(Many process mining tools reveal the nature of manual transactions. For example, in a specific task in a process half of the work may be manual and out of all the manual tasks, majority is due to one provider, person, or other variable.)* (Interviewee A)

> (24b) "*Yksinkertaisimmillaan se lähtee siitä, että se ei välttämättä edes pidä mitään process mining -työkalua mukana, että on perehdytty siihen dataan tarkemmalla tasolla.*" *(Most simply, and this does not necessarily require a process mining tool, people have familiarized themselves with the data in more detailed level.")* (Interviewee B)

> (24c) "*Se [prosessilouhinta] tarjoaa sen keskustelun alotuksen siihen prosessimäärittelylle. Sehän voi tarjota paljon ajatuksia siitä, miten se prosessi pitäisi määritellä tai parantaa tai muuta ennen kuin se voidaan automatisoida. […] Tuo tarjoaa semmosta mitattavaa totuutta siitä asiasta.*" *(Process mining provides an opening for the conversation on how the process should be defined or improved before automation. […] It brings kind of a measurable proof of the process.)* (Interviewee E)

> (24d) "*Jos toteutetaan tommonen pistokoe, niin me ollaan niin valtava talo, että me kuullaan vaan sen parin henkilön kokema kuvaus [prosessista] ja totuus voi olla jotain ihan muuta. Jos se on tommonen, että saadaan reaalidatasta sitä tietoa irti, niin kyllä se saadaan koko talon kattavasti sitä, että miten se nyt oikeasti se prosessi menikään.*" *(We are such a large organization that if we do a spot check, we will only hear the experiences of a couple of people on the process while the*

reality can be something different. With real data we can get a wide understanding about how the process really works in the organization.) (Interviewee F)

(24e) "*I would say the main benefit [of process mining] is the discovery and planning. So that we have higher quality discovery prioritization. We can do larger discoveries because we can see activities being performed across different units.*" (Interviewee I)

Example (24a) highlights some process insights that can be received from process mining. These insights are especially useful when looking for the root causes behind the problems or inefficiencies in the process. Similarly, examples (24b), (24c), and (24d) emphasize the influence of real data for process understanding. Example (24b) states that focusing on the data does not necessarily even require a process mining tool to be used, but as discussed in examples (24c) and (24d), process mining is able to effectively reveal the reality of the process instead of relying on process participants' opinions. This on the other hand results to an organization-wide and high-quality process discovery mentioned in example (24e). Such insights can be used to define the process for RPA or to spot needs for process redesign before automation can be effectively applied to the process as noted in example (24c). However, it is important to keep in mind as Interviewee C brought up, PM is likely most beneficial for large organizations that do not have well-structured processes:

"*Sillon jos sul on iso organisaatio, missä monessa paikassa tehdään asioita ja ehkä vielä vähän eri tavalla samoja asioita, niin vois kuvitella et siitä [prosessilouhinnasta] on kovinkin paljon hyötyä. Mut sillo jos sulla on keskitettyy toimintaa ja siel suurin piirtein tiedetään, miten ne asiat hoidetaan ja […] et miten niitä asioita tehdään niin siellä puolella vähä ehkä kyseenalaistasin et onko hyötyjä.*" *(If you have a large organization where there are many activities done in different ways, you could say that process mining is very beneficial. However, if you have a lot of centralized activities and those activities are somewhat familiar, in that case, I would maybe question a little bit if there is that much benefit in process mining.)* (Interviewee C).

PM also helps the users by revealing problems in the process. Typically, the problems are found after a high-level understanding of the process is achieved with the help of PM as noted by Interviewees A and B:

> "*Se [prosessilouhinta] paljastaa […] niitä nykysen prosessin aiheuttamia haittoja liiketoiminnalle ja sit niiten eliminoinnin avulla [saadaan liiketoimintahyötyjä].*" *(PM discovers the drawbacks of the current process to the business and by eliminating those drawbackss, business benefits can be realized.)* (Interviewee A);

> "*[…] process mining -työkalun käyttäminen sen kokonaiskuvan saamiseksi, niiden pullonkaulojen tunnistamiseksi ja siitä sitten automaation rakentaminen.*" *(PM tool can be used to build an overview, to identify bottlenecks, and after that automation can be created.)* (Interviewee B).

Discovering the problems in the process is necessary to successfully deploy RPA, or any other change, to a process. This is because automating a process that does not function properly only creates errors more efficiently as discussed in sub-section 2.2.4. Example (25) below introduces what kind of insights the interviewees have received with PM.

> (25a) "*Ohjelmistorobotiikassakin on tärkeää tietää virtaukset, et missä se massa menee. Kumpi on 80%, kumpi on 20%. Näis virtauksissa ja pullonkauloissa ja variaatioissa se [prosessilouhinta] on tosi hyvä.*" *(Knowing the flows is important for RPA. Understanding which flow is 80 % or 20 % of the mass. PM is very good with these flows and variations.)* (Interviewee F)

> (25b) "*We also use it [PM] for input when looking at a standardization of a process. When we look to automate it [the process], we look to see, is this the main variant or are there other variants we can try to capture and also make sure the inputs and outputs are standard. It helps with the solution design in that sense.*" (Interviewee I)

> (25c) "*[…] we can see all these variations from the PM. […] We can see how many things we do repetitively, incorrectly, inefficiently, and we spend our time*

there. […] We can see the bottlenecks, the process imperfections I would say." (Interviewee H)

(25d) "*Jos me havaitaan, että täs on valtava määrä eri variaatioita, sekin jo varmasti vaikuttaa siihen, millä lähestymistavalla prosessia lähetään kehittää. […] sitten myös saman tien niitä pullonkauloja, joihin voidaan keskittyä tarkemmin.*" *(If we notice that there is a huge amount of different variations, it definitely impacts on how we improve the process. We can also identify bottlenecks to focus on.)* (Interviewee G)

Some of the drawbacks that can be discovered with PM are presented in example (25c). Discovering the process flows and variations is seen important for RPA as it has a lot to do with the standardization of a process (25a & 25b). The amount of variations discovered with PM was seen to also influence the way how a process would be improved (25d).

Discovering the process inefficiencies and variations with PM are very helpful when identifying candidates for RPA as can be seen from the comments in example (26) below.

(26a) "*Must sillon ruetaan puhumaan just oikeesta asiasta, kun process miningin avulla katotaan, mitä pystyy automatisoimaan. Sielt ei tuu ne, "perjantaisin yksi henkilö tekee 15 minuuttia" -tyyliset jutut. Ne ei nouse pintaan ja se niiku auttaa fokusoimaan oikeeseen asiaan.*" *(In my opinion, we are talking about the real stuff, when we look at what can be automated with PM. The cases where one employee spends 15 minutes of their time on each Friday do not come up. PM helps to focus on the right things.)* (Interviewee A)

(26b) "*I would say that the biggest benefit we found with process mining and RPA is the prioritization of our automation. So far, we've been just discussing with the business feels and how to find areas for automation. But now we can actually see at a process level where there is the most manual work that's repetitive and we can actually see where it's been done and then do a manual discovery there.*" (Interviewee I)

(26c) "*I do know from industry peers […] that they've used process mining and those discovery functionalities to identify good use cases for automation. Because they understood better the inefficiencies in the process and by then going deeper in some of the mitigations to avoid such inefficiencies is automation.*" (Interviewee J)

(26d) "*[Prosessilouhinta] tuo lisää dataa päätöksenteon tueksi, että mitä automatisoidaan ja minkälaisia tuloksia ne automaatiot on saanu aikaan ihan oikeesti.*" *(PM brings more data to support decision making for automation and shows what kinds of benefits the automations have brought in reality.)* (Interviewee B)

As noted in sub-section 2.4 and highlighted by example (26c), RPA is one way to improve a process and by understanding the drawbacks of the current process, it is easier to decide where RPA should be applied. Example (26a) brought up that with PM, it is easier to focus on the most important processes for automation. Examples (26b) and (26d) continue this view by putting emphasis on PM's ability to support decision making with real facts of the process. Interviewee B continued this point with the additional benefit of being able to monitor the real results of automation on the process.

In fact, as can be seen from Figure 17, monitoring the impact and performance of both RPA and process was mentioned quite many times in the interviews. Example (27) introduces some of these comments.

(27a) "*[…] jos meillä prosessilouhinnanvälineet on käytössä ja pystytään sieltä esimerkiksi erottamaan ohjelmistorobotin tekemät työnkulut, niin kyllähän se varmasti on yksi apu siinä monitoroinnissa.*" *(If we have PM tools in use and we can separate the workflows executed by RPA, it certainly is useful for monitoring.)* (Interviewee F)

(27b) "*[…] there are dashboards in [process mining] which allow me to see this automation level and the automation level per processes. […] looking on dashboards and analyzing data and trying to increase this automation level within these processes.*" (Interviewee H)

> (27c) "*So, it's seeing how are they actually performing and improving the process lead times and automation rates. We know the bots are processing a lot based on the RPA logs and the business indicators. But, from the process level we don't follow up as much on the output. […] We can also do benchmarking for automation rates, so we can create targets for those. […] we've compared processes like one process in our intra-company finance team, where they've created a new automatic process and then they're trying to get people to switch to it, so we could show them the difference and the benefits.*" (Interviewee I)

As shown in example (27a), PM is able to separate workflows between different process participants. This also includes separating automated and manual work which can be used to specifically analyze RPA. With the possibility to separate automated and manual tasks, it is possible to create KPIs for automation targets as done by Interviewee H in example (27b). Such KPIs can then be used benchmark organization's processes to further improve them as presented in example (27c). Benchmarking can also be useful when trying to convince people to use RPA. Furthermore, example (27c) highlights the benefit of using PM to monitor robots instead of the RPA logs since those logs are not able to provide insights on the process level as PM does. Interestingly at the same time, Interviewee I acknowledges that they could use PM more for monitoring purposes.

To sum it up, the benefits of PM are to first generate a fact-based understanding of a process. This understanding includes discovering the process inefficiencies and the different process variants of the process. Secondly, with the help of the fact-based process understanding, candidates for RPA (and other automation) can be identified and the best prospects can be selected based on real data of the process. Thirdly, PM allows business users to monitor the performance of processes and RPA working on these processes. This insight helps organizations to find areas for further improvement, potentially with automation techniques such as RPA.

4.4.2 Challenges and limitations of PM

The interviewees came up with various limitations and challenges for using PM in RPA domain. These limitations and challenges have been divided into three categories presented in Figure 18 below. The most notable limitation is that PM does not necessarily discover all the activities that would be important for RPA. In terms of challenges, many of the received comments were concerning being able to actually use the outputs of PM which is true for RPA and other performance improvement initiatives.

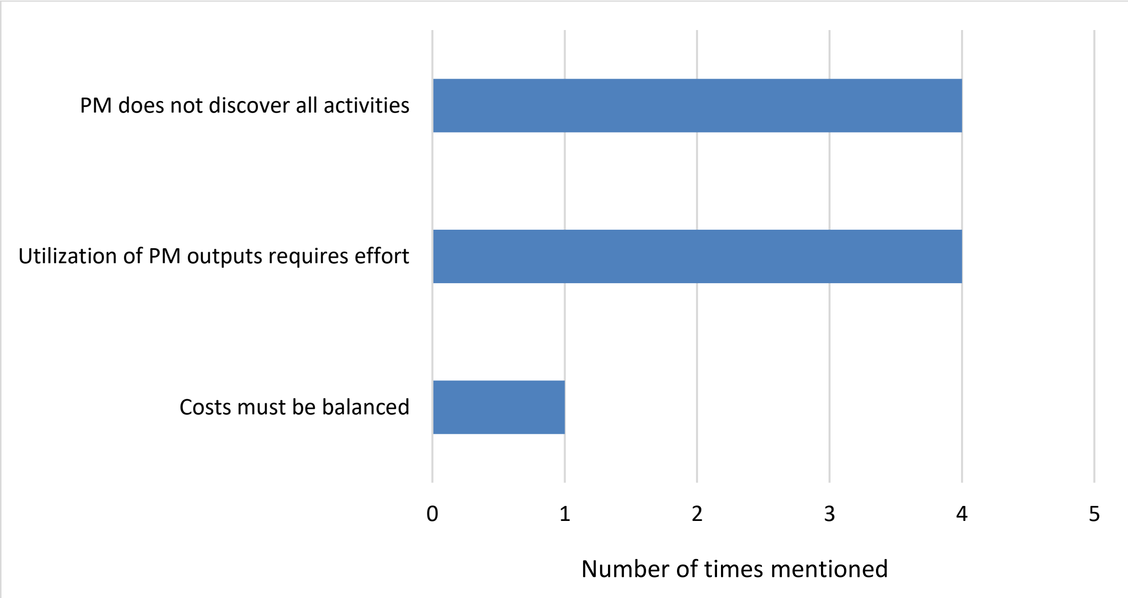

Figure 18. The challenges and limitations of PM in RPA.

Examples of general PM challenges and limitations are shown in example (28):

> (28a) "*[…] tietysti se prosessilouhinnan tulos, tehtiin se millä välineellä tai menetelmällä tahansa, niin sehän on suoraan verrannollinen siihen, kuinka laadukasta meidän data ja meidän datan tallennus, niiku lokitus, on.*" *(Obviously, the outputs of PM are directly related to the quality of the data we have collected.")* (Interviewee G);

> (28b) "*Se [prosessilouhinta] vaatii sitä prosessiosaamista, se vaatii sitä teknistä osaamista ja datan ymmärtämistä, se vaatii sitä automaatio-osaamista. Eli se ei ole mikään helppo harjotus.*" *(PM requires process knowledge, technical and data knowledge, and automation expertise. It is not an easy task.)* (Interviewee B);

> (28c) "*We are looking at a process level, but our engagement and how our organization works is, we have managers who manage teams that perform activities. Getting them to talk across units is difficult. […] Hard part is getting them to look at the process mining model as the truth.*" (Interviewee I).

Interviewee G in example (28a) points out that all the results and findings of PM are related to the quality of the source data. This would imply that with bad quality data, the PM results may not be able to reflect the reality. In addition to requiring good data and data knowledge, example (28b) lists other requirements for the user of PM. Interviewee B highlights that PM is not an easy task in terms of required knowledge. Interviewee I in example (28c) on the other hand recognized difficulties in getting the team managers to treat the PM results as the real truth. Another challenge is to get these managers to communicate between one another across the organization.

The above challenges are true for all PM use cases. In order to study what exactly are the limitations of PM for RPA, example (29) introduces various findings that cause PM to not be able to provide all the necessary results for RPA.

> (29a) "*[...] prosessilouhinnassahan lähtödatanaha on jonkinlainen loki. Ja sehä muodostaa tästä logista sitte prosessia. RPA:han taas on laajempi käsite kuin se, että tehdään tietyn järjestelmän login pohjalta olevia asioita. […] se taas potentiaalisesti rajottaa sitä näkyvyyttä siihen, mitä siinä prosessissa tapahtuu, koska se horisontti on se logi. Siinä ei sitte taas nää muuta kun ne asiat, mitkä tallentuu sinne järjestelmän logiin.*" *(The source data in PM is some kind of an event log that is transformed into a process. RPA on the other hand is a broader subject than doing activities according to an event log. This potentially limits the visibility of what happens in the process since the horizon with PM is the event log. You only see the activities recorded into the event log.)* (Interviewee E)

> (29b) "*Jos mietitään ohjelmistorobottia, niin sehä pitää olla kuvakaappaus per kuvakaappaus per kuvaruutu ja prosessilouhinnassahan ei mennä näyttötasolle kumminkaan. […] Eihän prosessilouhinta sinänsä kerro, että tarvitaanko työtehtävässä päättelyä tai harkintaa tai jotain muuta sellasta, mikä ei sovi automatisoitavaksi.*" *(For RPA, we need to have information on the screenshot level and PM does not go to that detail. Also, PM does not tell whether the task requires reasoning or consideration or something else that is not automatable.)* (Interviewee F)

(29c) ”*We are not seeing the whole picture with process mining. We're seeing the high-level activities that touch the main applications. […] So really the hard part is just translating what we capture in process mining to actually use in RPA design.”* (Interviewee I)

(29d) *”[...] you will not get the right use cases directly out of it [PM] […] There might be even transactions which are not covered by process mining.*” (Interviewee J)

As already noted in example (28a), PM needs good data for relevant process analysis. The quality and scope of this data is relevant for RPA, too. Interviewee E noted in example (29a) that PM is limited to the data in IT systems while RPA also considers activities not necessarily linked to these systems. Similar findings are observed in example (29b), (29c), and (29d). In example (29b) Interviewee F brings up that PM does not analyze the process on a fine level of detail, nor does PM tell the user anything about the requirements for certain tasks. Without these details it is challenging to use PM results for designing RPA as pointed out in example (29c) by Interviewee I. Since PM is not able to cover all the transactions, finding all the correct use cases of RPA alone with PM is not possible according to Interviewee J.

Lastly, the final subject to consider is the cost of both the PM and the RPA software compared to their estimated benefits. This subject was brought up by Interviewee B:

“*Ne elementit [RPA + PM] pitää olla järkevässä mittakaavassa niihin saatuihin hyötyihin nähden. Se tarkottaa sitä et pitää olla osittain uudelleenkäytettäviä ja standardisoituja elementtejä, jolloin sitä prosessilouhintaa pystytään tekemään. Se tarkoittaa myöskin sitä, että pitää löytää hyvin konkreettinen linkki näitten kahen aihealueen välillä käytännöntasolla.*” *(The RPA and PM elements need to be in a reasonable scale compared to the received benefits. This means that there needs to be partly re-usable and standardized elements. Then we can do PM. It also means that a concrete link must be found between RPA and PM on the practical level.)* (Interviewee B).

According to this comment, the practical usefulness of PM needs to be carefully considered. Interviewee B emphasizes that the RPA robots should be standardized and re-usable to make PM possible. Standardization of RPA is indeed important as noted in sub-section 2.2.7 when discussing about common modules for RPA. However, it is important to note, as discussed in sub-section 2.3.3 and show in Figure 11, process automation is only one of the many PM use cases. Indeed, the cost of PM still needs to be balanced with its benefits, but all of the benefits should be considered, not only the benefits brought to automation.

The limitations and challenges of PM mainly concern the quality and availability of data in the IT systems that are used to build PM models. As PM is able to only use the data available in the model to create analysis, the scope of PM may not be the same as RPA's. This is likely one factor behind the lack of trust that PM receives from business users. Another factor might be the fact that PM is not a simple task but requires knowledge of many fields to properly use it. Therefore, according to interviews, the main limitation and challenge for RPA is that PM is only able to show the high-level activities and processes of the organization while the scope of RPA requires knowledge on activities at detailed level.

5 DISCUSSION

This chapter combines the literature review with the interview results to answer the research questions. The research questions were partly answered in the literature synthesis in section 2.4, but in this chapter, these answers are extended with the findings from the interviews. The interview results mainly support the existing literature, but there are some interesting findings in the interviews that were not highlighted or found in the existing literature. Furthermore, there are many differences with the emphasis on specific areas concerning RPA or PM such as the importance of specific benefit of RPA.

The findings are discussed in the order of the research questions. This means that first, in section 5.1, benefits of RPA are considered to answer RQ1. Second, in section 5.2, focus is moved to the pre-requisites of successful RPA to answer RQ2. Thirdly, PM's influence on RPA is discussed and a revised RPA lifecycle extended with PM use cases is presented to answer RQ3. After answering the research questions, the reliability and validity of the research is evaluated. Lastly, the areas for further research are proposed.

5.1 The benefits of RPA

Table 6 compares the benefits of RPA found from the literature to those that rose up in the interviews with people with practical experience of RPA. The benefits found in the literature were already discussed in section 2.4. The benefits are divided into quantitative and qualitative benefits as previously done in section 2.4.

Table 6. Comparison of the benefits of RPA based on literature and interviews.

Quantitative benefits found in the literature	**Quantitative benefits based on practice**
Fast return on investment	Fast return on investment
Cost savings from increased productivity	Cost savings
Cost savings from salary	
Savings from reduced amount of errors	
Qualitative benefits found in the literature	**Qualitative benefits based on practice**
Improved employee satisfaction	Improved employee satisfaction
Improved process standardization	Improved process standardization
Improved customer satisfaction	Improved process quality
Improved flexibility	Catalyst for BPI and automation

The quantitative benefits of RPA can be roughly divided to two parts: cost reductions or savings and fast return in investment. The fast return on investment is especially true when compared to other automation options using the more traditional BPA methods that work in the back-end systems (Lacity & Willcocks 2016a; Lacity & Willcocks 2016b; Hallikainen et al. 2018). The difference between RPA and BPA is discussed more in detail in sub-section 2.2.6. Both the literature and the interview findings show that RPA has faster ROI than BPA.

The cost savings discussed in the literature were divided into three parts based on how the savings were received. These ways are salary, productivity, and reduction to errors. (Asatiani & Penttinen 2016; Lacity & Willcocks 2016a; Lacity & Willcocks 2016b; Aguirre & Rodriguez 2017; Suri et al. 2017; Hallikainen et al. 2018; Kääriäinen et al. 2018; Ratia et al. 2018; Cooper et al. 2019; Huang & Vasarhelyi 2019; Kokina & Blanchette 2019) The interviewees did not specifically divide the cost saving to such types. Instead, they referred to cost savings more generally. This means that it is very likely that all the three sources are experienced in practice as well. On the other hand, the interviewees did emphasize the importance of the cost savings which was not the case in the literature. The interviewees claimed the cost savings to be the most important benefit of RPA to consider and some interviewees said that it is an enabler for many other benefits in the qualitive side. For example, cost savings are the most important benefit to consider when building a business case for automation candidates in the process analysis and selection phase.

In the qualitative benefits, both improved employee satisfaction and improved process standardization were found from the literature and the interviews. Employee satisfaction is improved as human workers are able to move from simple routine work into work that requires human judgement and consideration (Willcocks et al. 2015b; Lacity & Willcocks 2016a; Suri et al. 2017; Hallikainen et al. 2018; Kääriäinen et al. 2018; Moffitt et al. 2018; Ratia et al. 2018; Cooper et al. 2019; Huang & Vasarhelyi 2019; Kokina & Blanchette 2019). Process standardization, on the other hand, is improved as the organizations applying RPA become more focused on their processes. In addition, in order to build a successful RPA, the processes need to be standardized which obviously plays an important role in improved process standardization. (Willcocks et al. 2015a; Lacity &

Willcocks 2016a; Aguirre & Rodriguez 2017; Suri et al. 2017; Cooper et al. 2019; Kokina & Blanchette 2019)

Improved customer satisfaction (Willcocks 2015b; Kääriäinen et al. 2018; Ratia et al. 2018) or improved flexibility (Asatiani & Penttinen 2016; Lacity & Willcocks 2016b; Aguirre & Rodriguez 2017; Suri et al. 2017; Jimenez-Ramirez et al. 2019) were not directly mentioned in the interviews. Instead, some interviewees were concerned that if the robot breaks for some reason, it is no longer possible to replace it with human workforce. This finding highlights the need for backup systems for RPA, but also somewhat contradicts the flexibility statements found from the previous literature. Improvement of customer satisfaction was not directly mentioned likely because it is a sum of many aspects such as improved quality. Indeed, improved process quality was the most often mentioned benefit of RPA in the interviews.

Due to the better process standardization, the quality of processes is also increased as RPA is introduced to the processes according to the interviews. When RPA is applied to a process, the amount of process variations has to be minimized. This means that process outputs have less deviation and the problems in the process are easier to identify. RPA was also reported to reduce the amount of human error since the robot does not get tired of monotonous tasks that typically lead to mistakes. These factors play an important role in improving process quality with RPA.

Another interesting benefit of RPA not cited in the literature was the finding that RPA works as a catalyst for process improvement and automation. Since the robots are able to gather very detailed information of activities which was not available before, organizations are able to find new areas to improve on. In addition, the speed of traditional BPA implementations is improved as organizations find new opportunities for automation through RPA. This way, RPA is able to further improve the quality and performance of business processes.

The literature review and the interview results introduce mostly similar benefits of RPA. The importance of cost savings was emphasized in the practical world as it is behind many of the other benefits. However, the sources for cost savings were more accurately described in the literature. The qualitative benefits were found to be mostly the same for both the literature and the interviews. An interesting finding from the interview was that by implementing RPA, process improvements and automation are considered more often. This is likely a driver behind the improved process quality mentioned in most of the interviews.

5.2 Pre-requisites of RPA

The pre-requisites of RPA were previously divided into pre-requisites for the process and for development in section 2.4. Based on the practical experiences received from the interviews, this categorization is revised to pre-requisites for management, operations, and IT & process landscape as shown in Table 7. First, managerial pre-requisites that guide the RPA implementation are considered. Next, there are operational activities that need to be taken care of for successful RPA. Lastly, there are pre-requisites for the IT and process landscape that affect the success of RPA and need to be considered when implementing RPA.

Table 7. Comparison of the pre-requisites of RPA based on literature and interviews.

Managerial pre-requisites found in literature	**Managerial pre-requisites based on practice**
Strategic targets for RPA	Understanding the capabilities of RPA
Clear responsibilities across the organization	Strategic targets for RPA
Selecting the best processes to automate	Sufficient resources to implement RPA
Operational pre-requisites found in literature	**Operational pre-requisites based on practice**
Communication and education about RPA	Training, education, and communication about RPA
Detailed process definition	Detailed process definition
IT & process landscape pre-requisites found in literature	**IT & process landscape pre-requisites based on practice**
Standardized process	Backup system for RPA
Digital environment	Stable IT systems
Process with high-volume of rule-based tasks	Scalable technical infrastructure for RPA

The managerial pre-requisites discussed in the literature focus on choosing the best use cases for RPA and setting up clear responsibilities in the organization (Fung 2014; Willcocks et al. 2015a; Willcocks et al. 2015b; Asatiani & Penttinen 2016; Lacity & Willcocks 2016a; Suri et al. 2017; Penttinen et al. 2018; van der Aalst et al. 2018; Cooper et al. 2019). An important addition to these pre-requisites emphasized in the interviews is allocating sufficient resources for RPA's implementation. For example, all of the necessary users such as SMEs must have enough time allocated to RPA so that they can really focus on RPA's implementation. All these three aspects require proper and realistic strategic targets and commitment for RPA by the management of the organization. Furthermore, in order to be able to set realistic targets for RPA, the management needs to understand the capabilities of RPA. This, on the other hand, can be received with training and education about RPA which is an operational pre-requisite.

The operational pre-requisites in the literature identified that communication and education about RPA generally are needed to prevent the possible confusion and fear towards RPA among employees (Willcocks et al. 2015b; Asatiani & Penttinen 2016; Lacity & Willcocks 2016a; Suri et al. 2017; Hallikainen et al. 2018; Cooper et al. 2019). This finding was extended in the interview results with the importance of communicating the management's plans and strategy for RPA to the rest of the organization. Education about RPA is needed to be able to set realistic goals for RPA and to identify the most suitable use cases for RPA as users begin to understand what the benefits and disadvantages of RPA are (Willcocks et al. 2015a; Willcocks et al. 2015b; Kääriäinen et al. 2018; Kokina & Blanchette 2019). In addition, detailed process definition was found as an important pre-requisite in both the literature (Suri et al. 2017; Hallikainen et al. 2018; Moffitt et al. 2018; Kääriäinen et al. 2018; Huang & Vasarhelyi 2019; Kokina & Blanchette 2019) and the interviews. The detailed process definition explains how the process is executed on a task level which is required to configure RPA. Detailed process definition also helps to spot the process variations that may otherwise likely rise up later during the testing phase of development, thus prolonging the implementation of RPA (Lacity & Willcocks 2016a; Moffitt et al. 2018; Kokina & Blanchette 2019). Co-operation across the organization is required to document and define the process. Moreover, the detailed process definition combined with the understanding of RPA's benefits and disadvantages help organizations to choose the best use cases for RPA and to avoid use cases not suitable for RPA.

Pre-requisites for the process and IT landscape were also observed. These pre-requisites were somewhat different between the findings in the literature and the interviews. Pre-requisites found in the literature emphasized process characteristics. The literature highlighted the importance of standardized processes with digital environment and high-volume of simple tasks in the process. (Fung 2014; Willcocks et al. 2015a; Asatiani &

Penttinen 2016; Lacity & Willcocks 2016a; Aguirre & Rodriguez 2017; Hallikainen et al. 2018; Kääriäinen et al. 2018; Moffitt et al. 2018; Cooper et al. 2019; Huang & Vasarhelyi 2019; Kokina & Blanchette 2019) On the other hand, results of the interviews did not have such an emphasis on the process characteristics, although some interviewees did mention that they are important, too. The interviewees were more concerned about the scalability and continuity of RPA in their organizations. Backup systems for RPA are needed as it is not possible to replace a broken robot with human workforce. Stable IT systems, also discussed in the literature in section 2.2.6 (Penttinen et al. 2018), are needed as frequent updating of the robots increases costs of operation. Lastly, the technical infrastructure on which RPA is built on should be scalable to the entire organization (Asatiani & Penttinen 2016). The reason for the difference between the literature and interview answers likely is that the interviewees take the process characteristics for granted and did not specifically mention them because of that. The fact that some of the interviewees did mention some of the process characteristics would suggest this to indeed be the case.

As can be seen above, the pre-requisites for different categories are related to each other. This means that in order to have a successful RPA, managerial, operational, IT and process related pre-requirements need to be met. Shortage in any of the fields can hinder the implementation of RPA or restrict the potential benefits to be gained from RPA. Lastly, it is important to monitor the robot's output to realize the benefits and to spot needs for improvement.

5.3 Process mining's influence on RPA

RQ3, how can process mining influence the efficiency of RPA implementation, is answered based on the findings in the literature and the interview results presented in section 4.4. The literature introduced the basics of PM in section 2.3 and some PM use cases for RPA domain were found in section 2.2 (Jimenez-Ramirez et al. 2019; Kokina & Blanchette 2019) as well. As already discussed in sub-section 2.3.3, PM has many use cases in business. Out of the presented PM use cases, this section focuses on process automation specifically with RPA.

Currently, there exist very few studies on the combination of RPA and PM. Some studies (Jimenez-Ramirez et al. 2019; Kokina & Blanchette 2019) mentioned that PM can be used to help with implementing RPA. In order to understand how PM can influence the efficiency of RPA in achieving its benefits, the challenges of RPA must be considered. As it turns out, many of these challenges can be overcome with the help of PM. In sub-section 2.4.1, RPA lifecycle (see Figure 12) was introduced based on the findings in the literature review. In this section, the RPA lifecycle is extended and steps that can benefit from PM are highlighted according to the interview results. The revised RPA lifecycle with PM use cases is illustrated in Figure 19 below.

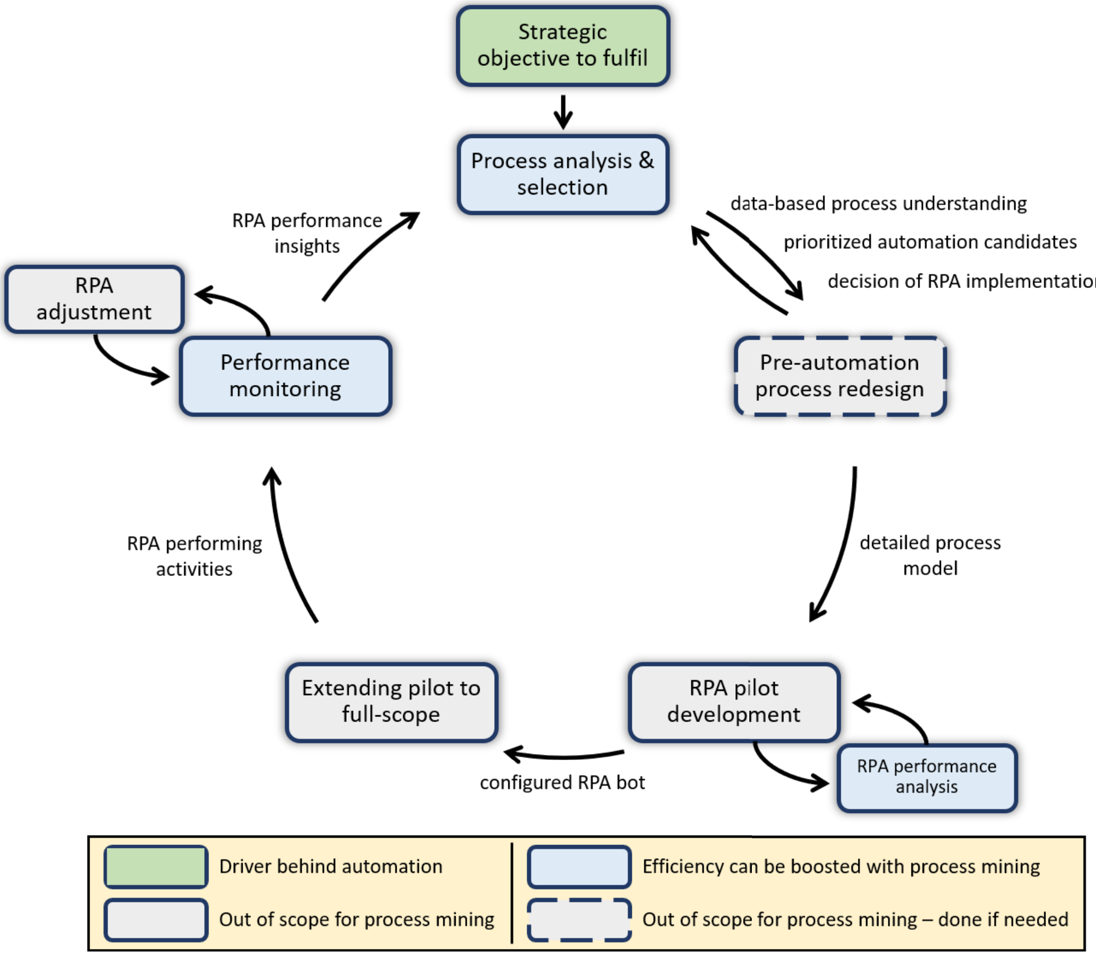

Figure 19. RPA lifecycle with PM use cases.

The RPA lifecycle begins with the need to fulfil a strategic objective such as decreasing the amount of manual labour. As discussed before in sections 2.1, 2.2, and 4.2, the focus on strategic targets is vital for successful RPA and process improvement in general (Hung 2006; Trkman 2010; van der Aalst et al. 2016; Meidan et al. 2017; Suri et al. 2017; Dumas et al. 2018; Kääriäinen et al. 2018; Santos et al. 2019). After setting the objective, the *process analysis & selection* step begins. During this step, the business cases for RPA for given processes are created along with process definitions. Lastly, the business cases are evaluated between one another and a decision of implementation is made. (Lacity & Willcocks 2016a; Suri et al. 2017; Kääriäinen et al. 2018; Moffitt et al. 2018; Kokina & Blanchette 2019) PM can help the process analysis and selection step by providing a data-based understanding of processes. This way, the organization can build the business cases with real data of the processes instead of relying in opinions of process participants. This allows organization to better prioritize the automation candidates, thus, creating better decisions on which processes to automate. Furthermore, PM helps organizations to define and model the processes with the process discovery tools available in PM software which further helps to prioritize the automation candidates (Rojas et al. 2016; Maita et al. 2018; Jimenez-Ramirez et al. 2019; Kokina & Blanchette 2019; Kerremans et al. 2020). For example, the amount of process variations can be easily spotted with PM and can be taken into consideration when making an implementation decision.

After a decision of implementation is made, the lifecycle moves to *pre-automation process redesign* step. This step is not mandatory, nor does it occur in every RPA implementation. This step only occurs when the 'as-is' process discovery reveals process inefficiencies that should be improved before applying RPA to the process (Lacity & Willcocks 2016a; Moffitt et al. 2018; Kokina & Blanchette 2019). Removing process inefficiencies prior to automation is important as implementing RPA would only create the same mistakes with better efficiency, thus, creating more waste (Hammer & Champy 1995; Trkman 2010; Ratia et al. 2018). After the process improvement is completed, the lifecycle moves back to the process analysis and selection step where the process is analysed again to verify that the improvement was successful. In case another improvement is needed the same actions take place. Only after the process works as it should, the lifecycle moves on towards RPA pilot development using the detailed process model created in the process analysis and selection step.

In the revised RPA lifecycle, the RPA development step is divided into two steps, pilot development and extending the pilot to full-scope. This is done to highlight that when applying RPA to a new process, it should be first tested within a smaller environment and extended to the whole process only after the robot is functioning as expected. During the

RPA pilot development step, the RPA bot is configured within a small part of the process. PM can be used to help the pilot development by analysing the performance of the RPA and going back to the develop the pilot as results of the analysis are received. In addition to the development work, organization should set up governance for RPA to help scaling the bot in the next step of the lifecycle. Governance includes setting up roles and responsibilities, training, scalable IT environment, and back-up systems for RPA (Willcocks et al. 2015; Lacity & Willcocks 2016a; Hallikainen et al. 2018; Moffitt et al. 2018; Kokina & Blanchette 2019). Furthermore, a common repository for RPA configuration should be maintained to help with scalability in the future.

After the RPA pilot is ready and receives acceptable results when analysed with PM, the pilot can be extended to full-scope. *Extending pilot to full-scope* applies the configured RPA bot to the rest of the process. The RPA governance setup in the previous step plays an important role in this step to be able to properly scale the RPA across the organization. If the governance is not handled properly, there is a possibility that some bots are left with no maintenance and supervision which can create problems later on as updates for RPA are needed. After the RPA is extended to full-scale, the bots are performing activities as they are configured.

When RPA is performing activities, *performance monitoring* step ensures that they are working as expected (Huang & Vasarhelyi 2019; Kokina & Blanchette 2019). PM is very useful for monitoring the process and RPA performance as PM is able to consider the whole process whereas analysing RPA logs only gives information about the RPA bot in question. Such information can be used to express the benefits of RPA to further accelerate the automation journey of the organization. In case the process or RPA performance drops, or there is a change in the process or customers' behaviour (Kääriäinen et al. 2018; Cooper et al. 2019; Huang & Vasarhelyi 2019; Kokina & Blanchette 2019), *RPA adjustment* step takes place. This step considers only small tweaks to RPA and then returns back to the performance monitoring step. If there is a need for a larger modification of RPA, the lifecycle moves on to the process analysis and selection step where the lifecycle starts again with the addition of RPA performance insights provided by PM.

As described in this section, PM plays a supportive role in RPA domain. It is very helpful to get a big picture of the organization's processes which helps to identify needs for automation and to choose the best opportunities to implement first. One very helpful, but sometimes challenging, aspect of PM that came up during the interviews is that PM analyses and defines the processes with real data. This is helpful as the results are not affected by personal bias, but some of the interviewees had experienced challenges in getting people to trust these results. This is likely due to the reality being vastly different from the supposed level of performance. Monitoring the robots and the process performance, however, should be done with real data and is a major benefit of PM.

A major challenge for using PM in RPA domain that rose up especially in the interviews is the scope of PM. PM is only able to recognize high-level activities that are recorded to information systems. This means that the detailed-level activities that happen on the employees' screens and are not recorded, cannot be analysed currently with PM. A solution to this problem can be to use non-invasive monitoring techniques to produce a detailed event log for PM as done by Jimenez-Ramirez et al. (2019). Such technology is commonly called task mining and it could potentially be very useful for discovering the detailed process definition for RPA.

5.4 Assessing the results

Qualitative research can be evaluated by various means and it seems that there is no consensus among the scientific community on what is the correct way to evaluate qualitative research (Fossey et al. 2002; Golafshani 2003; Eriksson & Kovalainen 2008; Denzin 2009). For example, the evaluation criteria for qualitative research may change based on three basic positions on the issue of evaluative criteria: foundational, quasi-foundational and non-foundational (Denzin 2009). According to Patton (2002), *validity* and *reliability* are two factors which any qualitative researcher should be concerned about while designing a study, analysing results, and judging the quality of the study. Lincoln and Guba (1985) have substituted reliability and validity with the parallel concept of '*trustworthiness*' containing four aspects: credibility, transferability, dependability and confirmability as ways to assess qualitative research. Therefore, the quality and trustworthiness of this research is evaluated by adopting alternative but common criteria for qualitative research using the criteria introduced in Eriksson & Kovalainen (2008).

Namely, these criteria are *credibility*, *transferability*, *dependability*, and *confirmability*. (Lincoln & Guba 1985; Fossey et al. 2002; Patton 2002; Golafshani 2003; Eriksson & Kovalainen 2008; Denzin 2009)

Credibility is concerned about the trustworthiness of the results. Credibility of the results depend on the researcher's familiarity on the topic, sufficiency of the data used, and how strong links there are between the observations and conclusions. (Golafshani 2003; Eriksson & Kovalainen 2008; Denzin 2009) The researcher is fairly familiar to the topics discussed in this thesis. The literature review provided good theoretical knowledge about BPM, RPA, and PM. During the study, the researcher worked around PM for 7 months, improving the practical experience on the subjects of BPM and PM, however, the researcher has no practical experience on RPA. The interviewees chosen for this research come from diverse backgrounds which improves generalization and trustworthiness of the data. The comments used to draw conclusions are represented as quotations in the research, also containing divergent thoughts when emerged which also improves the credibility of the research. Therefore, the credibility of this research is on a satisfactory level.

Transferability reflects the similarities between this research and other prior research on the topic to find connections and similarity with the prior research (Eriksson & Kovalainen 2008). Transferability, therefore, considers how generalizable the research is. Generalization in a qualitative research is focused on the applicability of their findings. (Fossey et al. 2002; Patton 2002; Golafshani 2003; Denzin 2009) This research had similar findings of RPA's benefits and pre-requirements with the prior literature. Moreover, RPA was studied in section 2.2 according to a conceptual framework used in Santos et al. (2019) which ties the research closer to the prior literature. However, there is a lack of studies on integrating PM to RPA framework as done in this research. The integration of PM was done based on the findings of both the prior literature and the interviews. Therefore, the transferability of this research is on an acceptable level and the resulting RPA lifecycle with PM activities should be validated with future studies.

Dependability discusses the information offered to the reader whether the research process has been logical, traceable, and documented to establish the trustworthiness of the research. (Golafshani 2003; Eriksson & Kovalainen 2008) The dependability of this research is on a good level. The research process of this research is described in detail so replicating the study would be easy and would likely have similar results. As an example, the semi-structured interview questionnaires are available as an appendix. In addition, the variation between the interview results is quite low which further supports the hypothesis of future studies generating similar results. However, as some of the interviews were conducted in Finnish, a non-Finnish speaking researcher may receive slightly divergent answers due to interviewees ability to speak in English, for example. Furthermore, as both RPA and PM are new technologies and fast to evolve, the received answers are likely to change over time. Therefore, after a few years, the RPA lifecycle presented in this study could be outdated.

Confirmability is concerned about how the findings and interpretations are linked to the data easily in an understandable way for others. It refers to the idea that the data and interpretations of an inquiry are facts instead of imagination. (Eriksson & Kovalainen 2008) To ensure confirmability, the interview structure was kept open with an aim to answer the most important themes with the help of semi-structured questions. The empirical findings are openly discussed using quotations in the research and conclusions are drawn based on those results, hence, the results reflect the interviewees' thoughts. Some bias may be introduced to the result due to the fact that some of the interviewees worked primarily with RPA which would likely decrease the chances of them criticising RPA. Also, the researcher works with PM, thus, some bias may be introduced even though the results were drawn as objectively as possible. Therefore, the confirmability of this research can be considered to be on an adequate level.

As always, there are limitations to this study. This research only considers combining RPA with PM while it could be also combined with some other tools to reach the same goal. Another limitation is presented as the field of task mining was not discussed in more detail while it could be very helpful when used together with RPA. Moreover, RPA combined together with predictive capabilities such as Machine Learning or Artificial Intelligence was out of the scope of this study, although, their combination may be useful. Finally, this research only considered combining PM with RPA as an automation method while other means of automating processes exist.

5.5 Future research topics

As the researched concept is quite broad, there are many topics for future research. Firstly, future research could focus on a more detailed scope to each of the proposed use cases that combine RPA and PM technologies. Such research would be useful to validate and revise the presented RPA lifecycle (Figure 19) and to provide more insights about the best practices of a given use case. Furthermore, such insight could be useful for further development of PM software.

Secondly, future research could validate the functionality of the RPA lifecycle. The RPA lifecycle could be validated or revised based on studies that consider multiple different organizations. It would be very interesting to see what kind of effects take place when an organization already using RPA begins to use PM to support RPA's implementation. Likewise, it would be interesting to see how the RPA lifecycle performs when an organization begins to use both RPA and PM at the same time.

Thirdly, the possibilities provided by combining RPA with task mining or predictive analysis with the help of cognitive technologies such as Machine Learning and Artificial Intelligence could be studied. The addition of these technologies would likely speed up the development work of RPA. This again could improve the speed and successfulness of RPA implementations.

6 CONCLUSIONS

This chapter represents the research conclusions by presenting the key results of this research through the research questions set for this thesis. The main purpose of this research was to create knowledge and understanding on how process mining can be utilized to increase the efficiency of RPA. To support this goal, research questions were chosen to study the benefits and pre-requisites of RPA and how process mining can be integrated into RPA domain. Next, the findings of this research are summarized.

RQ1: What are the benefits of RPA?

The existing literature related to RPA was studied and interviews were conducted to gather knowledge of the benefits of RPA. The key results of both the literature and the interviews were combined and compared in Table 6. These findings help to understand the why RPA should be applied to business processes and what types of goals can be set for RPA.

The benefits of RPA were presented and discussed thoroughly in sections 2.2.1, 4.1, and 5.1. The benefits were divided into quantitative and qualitative benefits. The most important quantitative benefit was found to be cost savings acquired with RPA. The cost savings were especially emphasised in the interviews since it an enabler for many of the other benefits and is important for building business cases for RPA. The qualitative benefits were mostly found to support the existing literature. However, the increased flexibility cited in the literature was somewhat contradictory with the interview results. Furthermore, the interviews revealed that implementing RPA works as a catalyst for process improvement and automation in general which was not to be found from the prior literature.

RQ2: What are the pre-requisites for successful RPA implementation?

The prior literature was researched, and interviews were conducted to learn more about the disadvantages, challenges, requirements, and risks of RPA. These aspects were combined and analysed together to understand what the pre-requisites for successful RPA are. Knowledge about the pre-requisites of RPA is important for finding out how process mining could improve the efficiency of RPA.

The pre-requisites based on prior literature were first presented in section 2.4. These findings were expanded and revised in section 5.2. The revised pre-requisites of RPA are presented in Table 7. The pre-requisites were divided into three categories: managerial, operational, and IT & process landscape. A pre-requisite for management was found to be setting strategic targets for RPA and allocating enough resources for its implementation. This again requires sufficient knowledge about the capabilities of RPA. Based on this pre-requisite, one of the operational pre-requisites was found to be education and communication about RPA in order to increase knowledge of RPA. In addition, creation of a detailed process definition for RPA was often emphasised as a pre-requisite of operational nature.

Finally, the IT & process landscape was somewhat divided between the literature and empirical findings. The prior literature had more emphasis on the process characteristics that are suitable for RPA while the interviewees were more concerned about the IT landscape RPA is built on. Ideally, RPA is applied to standardized processes with digital environment and high-volume of simple tasks in the process within an IT landscape that is stable and scalable with a back-up system for RPA.

RQ3: How can process mining influence the efficiency of RPA?

The prior literature of process mining was researched to gather knowledge about how process mining works and where it can be applied. With this knowledge, interviews were conducted to further study the benefits, limitations, and challenges of using process mining together with RPA. Based on the knowledge gathered from both the existing literature and the interview results, an RPA lifecycle with process mining use cases was created (see Figure 19) to express where process mining can be used to improve the efficiency of RPA.

Process mining is useful for building an understanding of the end-to-end processes within an organization using real data from the processes. The data-based process understanding can be used to detect opportunities for automation and to support decision making when organizations select which candidates to automate first. Process mining is also able to support the development of RPA. First, process inefficiencies and variations that should be fixed prior to automating the process can be detected with process mining. Secondly, the performance of RPA can be analysed while the RPA bot is under development to ensure its smooth development. Lastly, after RPA is extended to full-scope, its performance and the results of automation for the process can be monitored and communicated with process mining.

REFERENCES

Arnheiter, E. D. & Maleyeff, J., 2005. The integration of lean management and Six Sigma. The TQM Magazine, 17 (1), p. 5-18.

Boenner, A., 2020. Bayer: Process Mining Supports Digital Transformation in Internal Audit. In: Reinkemeyer, L. (ed.) Process Mining in Action – Principles, Use Cases and Outlook. Cham: Springer, 207 p. ISBN 978-3-030-40172-6

Breuker, D., Matzner, M., Delfmann, P., & Becker, J., 2016. Comprehensible Predictive Methods for Business Processes. MIS Quarterly, 40 (4), p. 1009-1034.

Bryman, A. & Bell, E., 2007. Business research methods. 2nd edition. Oxford: Oxford University Press, 786 p. ISBN 978-0-19-928498-6

Buhrmann, C., 2020. Bosch: Process Mining—A Corporate Consulting Perspective. In: Reinkemeyer, L. (ed.) Process Mining in Action – Principles, Use Cases and Outlook. Cham: Springer, 207 p. ISBN 978-3-030-40172-6

Calvasina, R. V., Calvasina, E. J., & Calvasina, G. E., 1989. Beware The New Accounting Myths. Management Accounting, 71 (6), p. 41-45.

Cooper, L. A., Holderness, D. K. Jr., Sorensen, T. L., & Wood, D. A., 2019. Robotic Process Automation in Public Accounting. Accounting Horizons 33 (4), p. 15-35.

DAAAM International, ISBN 978-3-902734-20-4, ISSN 1726-9679, Vienna, Austria

Daniels, J. D. & Cannice, M. V., 2004. Interview Studies in International Business Research. In: Marschan-Piekkari R., & Welch, C. (eds) Handbook of Qualitative Research Methods for International Business. Cheltenham: Edward Elgar Publishing Ltd, p. 185-206. ISBN 1 84376 083 5

Davenport, T. H., 1993. Process innovation: reengineering work through information technology. Boston (MA): Harvard Business School Press, 337 p. ISBN 0-87584-366-2 de Leoni, M., van der Aalst, W. M. P., & Dees, M., 2016. A general process mining framework for correlating, predicting and clustering dynamic behavior based on event logs. Information Systems, 56, p. 235-257.

Deming, W. E., 1986. Out of the Crisis. Cambridge, MA: MIT Press, 507 p. ISBN 0911379010 9780911379013

Denzin, N. K., 2009. The elephant in the living room: or extending the conversation about the politics of evidence. Qualitative Research, 9 (2), p. 139-160.

Di Francescomarino, C., Ghidini, C., Maggi, F. M., & Milani, F., 2018. Predictive Process Monitoring Methods: Which One Suits Me Best?. In: Weske, M., Montali M., Weber I., vom Brocke J. (eds) Business Process Management. BPM 2018. Lecture Notes in Computer Science, 11080. Cham: Springer, p. 462-479. ISBN 978-3-319-98648-7

Dumas, M., La Rosa, M., Mendling, J., & Reijers, H. A., 2018. Fundamentals of business process management. 2nd edition. Berlin: Springer, 527 p. ISBN 978-3-662-56508-7

El-Wafi, K., 2020. Siemens: Process Mining for Operational Efficiency in Purchase2Pay. In: Reinkemeyer, L. (ed.) Process Mining in Action – Principles, Use Cases and Outlook. Cham: Springer, 207 p. ISBN 978-3-030-40172-6

Eriksson, P. & Kovalainen, A., 2008. Introducing Qualitative Methods: Qualitative methods in business research. 1st edition. London: SAGE Publications Ltd, 301 p. ISBN 9780857028044

Fossey, E., Harvey, C., McDermott, F., & Davidson, L., 2002. Understanding and evaluating qualitative research. Australian and New Zealand Journal of Psychiatry, 36, p. 717-732.

Fullerton, R. R. & McWatters, C. S., 2001. The production performance benefits from JIT implementation. Journal of Operations Management, 19 (1), p. 81-96.

García-Bañuelos, L., can Beest, N. R. T. P., Dumas, M., La Rosa, M., & Mertens, W., 2018. Complete and Interpretable Conformance Checking of Business Processes. IEEE Transactions on Software Engineering, 44 (3), p. 262-290.

Ghasemi, M. & Amyot, D., 2020. From event logs to goals: a systematic literature review of goal-oriented process mining. Requirements Engineering, 25, p. 67-93.

Golafshani, N., 2003. Understanding Reliability and Validity in Qualitative Research. The Qualitative Report, 8 (4), p. 597-607.

Hallikainen, P., Bekkhus, R., & Pan, S. L., 2018. How OpusCapita Used Internal RPA Capabilities to Offer Services to Clients. MIS Quarterly Executive, 17 (1), p. 41-52.

Hammer, M. & Champy, J., 1995. Reengineering the corporation: A manifesto for business revolution. Repr. London: Brealey, 231 p. ISBN 1-85788-056-0

Harmon, P., 2015. The Scope and Evolution of Business Process Management. In: vom Broke, J., & Rosemann, M. (eds) Handbook on business process management 1: Introduction, methods, and information systems. 2nd edition. Berlin: Springer, 186 p. ISBN 978-3-642-45100-3

Henriques, R., 2020. EDP Comercial: Sales and Service Digitization. In: Reinkemeyer, L. (ed.) Process Mining in Action – Principles, Use Cases and Outlook. Cham: Springer, 207 p. ISBN 978-3-030-40172-6

Huang, F., & Vasarhelyi, M. A., 2019. Applying robotic process automation (RPA) in auditing: A framework. International Journal of Accounting Information Systems, 35 (100433), p. 1-11.

Jansen, H., 2020. ABB: From Mining Processes Towards Driving Processes. In: Reinkemeyer, L. (ed.) Process Mining in Action – Principles, Use Cases and Outlook. Cham: Springer, 207 p. ISBN 978-3-030-40172-6

Jimenez-Ramirez, A., Reijers, H. A., Barba, I., & Del Valle, C., 2019. A method to improve the early stages of the robotic process automation lifecycle. In: Giorgini, P., &

Weber, B. (eds) Advanced Information Systems Engineering – 31st International Conference, CAiSE 2019 Rome, Italy, June 3-7, 2019 Proceedings. Cham: Springer, p. 446-461. ISBN 978-3-030-21290-2

Juran, J. M., 1989. Juran on Leadership for Quality: An Executive Handbook. New York, NY: The Free Press, 376 p. ISBN 0029166829 9780029166826

Kerremans, M., Searle, S., Srivastava, T., & Iijima, K., 2020. Market Guide for Process Mining. Gartner Inc., [online document], [Accessed 19.10.2020], Available from: www.gartner.com/en/documents/3991229

Kokina, J., & Blanchette, S., 2019. Early evidence of digital labor in accounting: Innovation with Robotic Process Automation. International Journal of Accounting Information Systems, 35 (2019), 100431.

Kääriäinen, J. (ed.), Aihkisalo, T., Halén, T., Holmström, H., Jurmu, P., Matinmikko, T., Seppälä, T., Tihinen, M. & Tirronen, J., 2018. Ohjelmistorobotiikka ja tekoäly – soveltamisen askelmerkkejä [online document]. Helsinki: Prime Minister's Office. 65/2018. Available from: http://julkaisut.valtioneuvosto.fi/handle/10024/161123 [Accessed 28.2.2020]. 65 p.

Lacity, M. C., & Willcocks, L. P. a, 2016. Robotic Process Automation at Telefónica O2. MIS Quarterly Executive, 15 (1), p. 21-35.

Lacity, M. C., & Willcocks, L. P. b, 2016. A New Approach to Automating Services. MIT Sloan Management Review, 58 (1), p. 40-49.

Lechner, P., 2020. BMW: Process Mining @ Production - Bringing Innovation to Production Processes and Beyond. In: Reinkemeyer, L. (ed.) Process Mining in Action – Principles, Use Cases and Outlook. Cham: Springer, 207 p. ISBN 978-3-030-40172-6

Leemans, S. J. J., Fahland, D., & van der Aalst, W. M. P., 2018. Scalable process discovery and conformance checking. Software System Modeling, 17, p. 599-631.

Leno, V., Polyvyanyy, A., Dumas, M., La Rosa, M., & Maggi, F. M., 2020. Robotic Process Mining: Vision and Challenges. Business & Information Systems Engineering, 2020, p. 1-14.

Leopold, H., van der Aa, H., & Reijers, H. A., 2018. Identifying Candidate Tasks for Robotic Process Automation in Textual Process Descriptions. In: Gulden J., Reinhartz-Berger I., Schmidt R., Guerreiro S., Guédria W., Bera P. (eds) Enterprise, Business-Process and Information Systems Modeling. Cham: Springer, p. 67-81. ISBN 978-3-319-91704-7

Lillig, G., 2020. Telekom: Process Mining in Shared Services. In: Reinkemeyer, L. (ed.) Process Mining in Action – Principles, Use Cases and Outlook. Cham: Springer, 207 p. ISBN 978-3-030-40172-6

Lincoln, Y. S., & Guba, E. G., 1985. Naturalistic inquiry. Beverly Hills: SAGE Publications Inc, 416 p. ISBN: 9780803924314

Maggi, F. M., Di Francescomarino, C., Dumas, M., & Ghidini, C., 2014. Predictive Monitoring of Business Processes. In: Jarke, M., Mylopoulos, J., Quix, C., Rolland, C., Manolopoulos, Y., Mouratidis, H., & Horkoff, J. (eds) Advanced Information Systems Engineering. CAiSE 2014. Lecture Notes in Computer Science, 8484. Cham: Springer, p. 457-472. ISBN 978-3-319-07881-6

Maita, A. R. C., Martins, L. C., Paz, C. R. L., Rafferty, L., Hung, P. C. K., Peres, S. M. & Fantinato, M., 2018. A systematic mapping study of process mining. Enterprise Information Systems, 12 (5), p. 505-549.

Márquez-Chamorro, A. E., Resinas, M., & Ruiz-Cortés, A., 2018. Predictive Monitoring of Business Processes: A Survey. IEEE Transactions on Services Computing, 11 (6), p. 962-977.

Meidan, A., García-García, J. A., Escalona, M. J., & Ramos, I., 2017. A survey on business processes management suites. Computer Standards & Interfaces, 51, p. 71-86.

Metsämuuronen, J., Luoma, P., Karjalainen, T. P., Reinikainen, K., Virtanen, J., Rantala, T., Remes, L., & Sandelin-Benkö, S., 2011. Laadullisen tutkimuksen käsikirja. E-book 1st edition. Helsinki: Methelp, 754 p. ISBN 978-952-5372-30-4

Moffitt, K. C., Rozario, A. M., & Vasarhelyi, M. A., 2018. Robotic Process Automation for Auditing. Journal of Emerging Technologies in Accounting, 15 (1), p. 1-10.

Myers, M. D., 2013. Qualitative Research in Business & Management. 2nd edition. London: SAGE Publications Ltd, 277 p. ISBN 978-0-85702-974-4

Nguyen, G-T., 2020. Siemens: Driving Global Change with the Digital Fit Rate in Order2Cash. In: Reinkemeyer, L. (ed.) Process Mining in Action – Principles, Use Cases and Outlook. Cham: Springer, 207 p. ISBN 978-3-030-40172-6

Parviainen, P., Kääriäinen, J., Honkatukia, J. & Fedeley, M., 2017. Julkishallinnon digitalisaatio – tuottavuus ja hyötyjen mittaaminen [online document]. Helsinki: Prime Minister's Office. 3/2017. Available from: http://julkaisut.valtioneuvosto.fi/handle/10024/80883 [Accessed 28.2.2020]. 90 p.

Patton, M. Q., 2002. Qualitative research & evaluation methods. 3rd edition. Thousand Oaks (California): SAGE Publications Inc, 598 p. ISBN 978-0-7619-1971-1

Penttinen, E., Kasslin, H., & Asatiani, A., 2018. How to Choose between Robotic Process Automation and Back-end System Automation?. In: Frank, U., Kautz, K., & Bednar, P. M. (eds) 26th European Conference on Information Systems: Beyond Digitization - Facets of Socio-Technical Change, ECIS 2018, Research Papers, 66, p. 1-14.

Polyvyanyy, A., Smirnov, S., & Weske, M., 2015. Business Process Model Abstraction. In: vom Broke, J., & Rosemann, M. (eds) Handbook on business process management 1: Introduction, methods, and information systems. 2nd edition. Berlin: Springer, 186 p. ISBN 978-3-642-45100-3

PricewaterhouseCoopers. 2017. Who minds the bots? – Why organisations need to consider risks related to Robotic Process Automation [online document]. Available from:

https://www.pwc.com.au/publications/assets/rpa-risk-controls.pdf [Accessed 30.9.2020] 10 p.

Ratia, M., Myllärniemi, J., & Helander, N., 2018. Robotic Process Automation - Creating Value by Digitalizing Work in the Private Healthcare?. In: Proceedsings of the 22nd International Academic Mindtrek Conference, Mindtrek 2018, Tampere, Finland, October 10-11. 2018. New York: Association for Computing Machinery, p. 222-227. ISBN 978-1-4503-6589-5

Reijers, H. A., Mendling, J., & Recker, J., 2015. Business Process Quality Management. In: vom Broke, J., & Rosemann, M. (eds) Handbook on business process management 1: Introduction, methods, and information systems. 2nd edition. Berlin: Springer, 186 p. ISBN 978-3-642-45100-3

Reindler, J., 2020. Siemens Healthineers: Process Mining as an Innovation Driver in Product Management. In: Reinkemeyer, L. (ed.) Process Mining in Action – Principles, Use Cases and Outlook. Cham: Springer, 207 p. ISBN 978-3-030-40172-6

Reinkemeyer, L., 2020. Process Mining in Action – Principles, Use Cases and Outlook. Cham: Springer, 207 p. ISBN 978-3-030-40172-6

Rojas, E., Munoz-Gama, J., Sepúlveda, M. & Capurro, D., 2016. Process mining in healthcare: A literature review. Journal of Biomedical Informatics, 61, p. 224-236.

Rowlson, M., 2020. Uber: Process Mining to Optimize Customer Experience and Business Performance. In: Reinkemeyer, L. (ed.) Process Mining in Action – Principles, Use Cases and Outlook. Cham: Springer, 207 p. ISBN 978-3-030-40172-6

Rozinat, A. & van der Aalst, W. M. P., 2008. Conformance checking of processes based on monitoring real behavior. Information Systems, 33, p.64-69.

Santos, F., Pereira, R., & Vasconcelos, J. B., 2019. Toward robotic process automation implementation: an end-to-end perspective. Business Process Management Journal, 26 (2), p. 405-420.

Saunders, M., Lewis, P. & Thornhill, A. 2016. Research methods for business students. 7th edition. Harlow: Pearson Education, 731 p. ISBN 978-1-292-01662-7

Shuckat, G., 2020. Schukat: Process Mining Enables Schukat Electronic to Reinvent Itself. In: Reinkemeyer, L. (ed.) Process Mining in Action – Principles, Use Cases and Outlook. Cham: Springer, 207 p. ISBN 978-3-030-40172-6

Snee, R. D., 2000. Six Sigma Improves Both Statistical Training and Processes. Quality Progress, 33 (10), p. 68-72.

Snee, R. D., 2010. Lean Six Sigma – getting better all the time. International Journal of Lean Six Sigma, 1 (1), p. 9-29.

Toor, T. P. S., & Dhir, T., 2011. Benefits of integrated business planning, forecasting, and process management. Business Strategy Series, 12 (6), p. 275-288.

van der Aalst, W. M. P., Ter Hofstede, A. H. M., Weske, M., 2003. Business Process Management: A Survey. In: Van der Aalst, W. M. P., Ter Hofstede, A. H. M., Weske, M., (eds) Business Process Management - International Conference, BPM 2003 Eindhoven, The Netherlands, June 26-27, 2003 Proceedings. Berlin: Springer, p. 1-12. ISBN 3-540-40318-3

van der Aalst, W. M. P., Reijers, H. A., Weijters, A. J. M. M., van Dongen B. F., Alves de Medeiros, A. K., Song, M., Verbeek, H. M. W., 2007. Business process mining: An industrial application. Information Systems, 32, p. 713-732.

van der Aalst, W. M. P., Van Hee, K. M., Van der Werf, J. M. & Verdonk, M., 2010. Auditing 2.0: Using Process Mining to Support Tomorrow's Auditor. IEEE Computer, 43 (3), p. 90-93.

van Der Aalst, W. M. P., et al. 2012. Process Mining Manifesto. In: Daniel F., Barkaoui K., Dustdar S. (eds) Business Process Management Workshops. BPM 2011. Lecture Notes in Business Information Processing, volume 99. Berlin: Springer, p. 169-194. ISBN 978-3-642-28108-2 van der Aalst, W. M. P., 2016. Process Mining – Data Science in Action. 2nd edition. Berlin: Springer, 452 p. ISBN 978-3-662-49851-4

van der Aalst, W. M. P., La Rosa, M., & Santoro, F. M., 2016. Business Process Management: Don't Forget to Improve the Process!. Business and Information System Engineering, 58 (1), p. 1-6.

vom Brocke, J., & Rosemann, M. (eds), 2015. Handbook on business process management 1: Introduction, methods, and information systems. 2nd edition. Berlin: Springer, 186 p. ISBN 978-3-642-45100-3

vom Brocke, J., Zelt, S., & Schmiedel, T., 2016. On the role of context in business process management. International Journal of Information Management, 36, p. 486-495.

Weske, M., van der Aalst, W. M. P., & Verbeek, H. M. W., 2004. Advances in business process management. Data & Knowledge Engineering, 50, p. 1-8.

Weske, M., 2012. Business Process Management: Concepts, Languages, Architectures. 2nd edition. Berlin: Springer, 403 p. ISBN 978-3-642-28616-2

Willcocks, L., Lacity, M. & Craig, A. a, 2015. Robotic Process Automation at Xchanging. The Outsourcing Unit Working Research Paper Series, June 2015, Paper 15/03, p. 1-26.

Willcocks, L., Lacity, M. & Craig, A. b, 2015. The IT Function and Robotic Process Automation. The Outsourcing Unit Working Research Paper Series, October 2015, Paper 15/05, p. 1-39.

Zipkin, P. H., 1991. Does Manufacturing Need a JIT Revolution?. Harvard Business Review, 69 (1), p. 40-48.

APPENDICES

Appendix 1. Interview frame and questions.

Background

1. How much experience do you have with RPA and/or process mining?

BPM

2. Do you have any type of process improvement framework/methodology in use?
3. Is there a corporate level center of excellence?
4. How process-centric would you describe your organization to be?

RPA in general

5. How would you describe RPA?
6. How would you describe the difference between RPA and traditional (back-end) process automation?
7. How would you describe the difference between RPA and Intelligent Automation?
8. How would you describe the automation maturity in your organization?
    a. individual task automation vs end-to-end process automation

RPA's implementation

9. What type of processes have you applied RPA to?
10. Does your organization use a framework for RPA?
    a. If yes, please describe it shortly
11. **How are opportunities for applying RPA identified?**
    a. Is there an "incubator" process where potential projects are identified? Is this an ongoing process or when does it occur?
12. **What kind of challenges have you encountered in RPA implementation projects?**
    a. **Biggest and most common ones?**
    b. **Are these related to a specific phase in an RPA implementation project?**
13. **Have you encountered any risks regarding RPA?**
14. **Have there been benefits to applying RPA?**
    a. **What are the benefits?**
15. How do you decide the optimal automation method (RPA vs. back-end)?

Process Mining

16. **Have you used process mining to support your automation initiatives?**
17. **How did you use process mining in RPA implementation?**
18. **Have you experienced any challenges or limitations when using process mining in RPA implementations?**
19. **What were the benefits of using process mining?**

Misc.

20. Does a clear roadmap/strategy for RPA adoption in the organization exist?
    a. Is RPA seen more as a tool or a scalable enterprise wide capability?

21. What kind of support did/does RPA receive from top management (C-level)?
    a. Is RPA linked to a larger strategic program? E.g. digitization or automatization program